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Assessment of Organic Emission Factors

Pacific Environmental Services, Inc.
Santa Monica, CA

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

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ASSESSMENT OF ORGANIC EMISSION FACTORS

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This report was developed to provide a prioritized listing of needs for improved organic emission factors and a synopsis of known projects underway, both within EPA and externally, which will provide basic data resources to support such improvements. A suggested outline of activities needed to accomplish these improvements is also provided. The report is expected to be utilized as an internal management tool, but also provides information which may be useful to persons with specific interest in organic emissions.

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by

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SUMMARY

This report presents the results of a survey of selected users of AP-42 to determine the deficiencies of this publication with respect to volatile organic emission factors. A priority listing of source categories was developed based on (1) mass of volatile organics emitted nationally, (2) number of individual sources, (3) population affected, (4) quality of existing emission factors, (5) needs as perceived by users, and (6) work underway to lead to improved emission factors. The highest priority categories were found to be:

Oil and gas production
Industrial surface coating
Petroleum tank storage
Petroleum refining
Degreasing
Leakage from gas distribution
Boilers, fossil fuel

Accomplished and current research is summarized for each of the top 19 priority categories. A plan is presented for January 1978 through December 1979, detailing an orderly sequence for preparing improved and updated sections for AP-42 based on the priority listing and the availability of new information.

CONVERSION FACTORS FOR METRIC UNITS

Metric Unit	Metric Name	Equivalent English Unit
Kg	kilogram (10^3 grams)	2.2046 lb
liter	liter	0.0353 ft^3
dscm	dry standard cubic meter	35.31 ft^3
scmm	standard cubic meter per min.	35.31 ft^3/min
Mg	megagram (10^6 grams)	2,204.6 lb
metric ton	metric ton (10^6 grams)	2,204.6 lb

In keeping with U.S. Environmental Protection Agency policy, metric units are used in this report. These units may be converted to common English units by using the above conversion factors.

Temperature in degrees Celsius (C°) can be converted to temperature in degrees Farenheit (°F) by the following formula:

$t°_f = 1.8\ (t°_c) + 32$

$t°_f$ = temperature in degrees Farenheit

$t°_c$ = temperature in degrees Celsius or degrees Centigrade

1.0 INTRODUCTION

The estimation of pollutant emission rates from each of the numerous sources found in typical communities is an essential step in the understanding of and amelioration of air pollution problems. These emissions are frequently estimated by applying an emission factor (emission rate per unit activity) to some measure of activity (production capacity, fuel usage, etc.). The most comprehensive information on emission factors is found in a document published by EPA, "Compilation of Air Pollutant Emission Factors," AP-42. This material was first published in 1972 and has been updated and expanded each year, or more often, since that time. This report deals with a plan for updating the AP-42 emission factors for volatile organic compounds (VOC)* and for expanding the coverage of AP-42 to include additional sources of VOC.

Originally, VOC emission factors were used in compilation of total hydrocarbon inventories that were used by control officials in implementation planning. The control of VOC emissions was undertaken as the most realistic way of controlling ambient levels of oxidant which exceeds the air quality standard in a majority of the air quality control regions (AQCR). As methods for predicting oxidant control requirements have become more sophisticated, the specifications for VOC inventories have become more exacting. At a minimum, present

*The emission factors in AP-42 are labeled "hydrocarbons" even though they include organic compounds that contain oxygen, nitrogen, and halogens as well as hydrogen and carbon. An attempt is currently being made to substitute "volatile organic compounds" (VOC) as a more accurate term; hence, this terminology is used throughout this report. The term "nonreactive organics" is used to indicate methane, ethane, 1,1,1-trichloroethane and trichlorotrifluoroethane (Table 1, page 35314, Federal Register, July 8, 1977); all other compounds are classified as "reactive organics."

inventories must be designed to differentiate between methane and other organics, and if the inventory must serve as input for photochemical modeling exercises, the inventory must be broken down even further into paraffins, aromatics, olefins, aldehydes, or other groupings. The emission factors in AP-42 were developed before these special needs existed and in many cases, therefore, the factors do not fulfill all the user needs.

Section 2.0 of this report summarizes the deficiencies and omissions of present AP-42 VOC factors as identified by numerous users of the volume. The following sections include an assignment of priority ratings to each source category, a summary of work recently completed or underway related to VOC emission factors, and a proposed plan for expediting the expansion and update of AP-42. This report does not include an evaluation of mobile source emission factors because these are the responsibility of a separate group within EPA and are outside the scope of this work assignment.

2.0 IDENTIFICATION OF DEFICIENCIES AND OMISSIONS IN AP-42

Users of AP-42 were interviewed to obtain their opinions on the adequacy of the VOC factors for their needs. A list of interviews is given in Appendix A. Their comments are summarized in the following paragraphs, and for convenience they are listed according to the applicable section numbers in AP-42.

- Section 1 - External Combustion Sources

  There is a need for reactive VOC factors for powerplants, large boilers, and large incinerators. This information is required for new source review to determine whether these sources may be subject to the emissions offset policy. Factors (total and reactive VOC) are lacking for sources that burn mixed fuel such as coal/refuse or oil/refuse. Factors for residential heaters -- hand-fired coal and oil fired -- appear to be based on old test data and may not be applicable to modern heaters of improved design. It would be useful to have all factors for residential heating put in a separate sub-section rather than including them with the factors for larger combustion sources. One agency indicated a need for VOC factors for military fire-fighting schools.

- Section 2 - Solid Waste Disposal

  No specific comments were received except for those related to fuel/refuse combustion as noted above.

- Section 3 - Internal Combustion Engine Sources

  Comments were made about the difficulties of using the factors for stationary internal combustion engines when duty cycles are not well defined. In addition, it is unclear whether the factors include evaporative emissions when these are not broken out separately or whether the factors are for exhaust emissions only.

- Section 4 - Evaporation Loss Sources

  Users of AP-42 differed in their opinions of the adequacy of emission factors for surface coating. Some wanted factors based on the number of units coated; others preferred factors based on the quantity of coating material used; and others were satisfied with factors of 2,000

pounds per ton based on the amount of solvent used. Some users wanted a discussion of the effect of heating on solvent emissions.

Many individuals expressed dissatisfaction with the factors for petroleum storage, transportation, and marketing, but most of these individuals had not studied the revisions of these sections that were published in Supplement 7 to AP-42. Those who were familiar with Supplement 7 were still dissatisfied with the treatment of vapor balance systems. The system needs to be considered as an entity (see Figure 3-2 in EPA-450/2-77-035 for example) because the storage tanks and delivery trucks are interconnected. This cannot readily be done in the present format of AP-42 with storage and transportation in two separate subsections.

A need was expressed for factors for solvent extraction operations -- cottonseed oil, for example -- where the factors were based on the amount of material extracted or the amount of the final product. Factors for solvent reclamation were also requested.

Comments were made about the difficulties of estimating emissions from tank truck gasoline loading terminals where part of the emission factors are in Section 4.3 and part are in Section 4.4. It was suggested that a section that treated loading terminals as an entity would be valuable. The situation is similar with respect to bulk plants except that Section 4.3 does not contain emission factors that are applicable to storage tanks as small as those commonly found at bulk plants. There is an even greater need, therefore, for a section that treats bulk plants as an entity.

- Section 5 - Chemical Process Industry

No specific suggestions were received for expansion or modification of this section. Several agencies commented on the difficulty of inventorying this industry because many plants change their processes on a monthly or seasonal basis as the demand for particular products changes.

- Section 6 - Food and Agricultural Industry

A general concern was expressed that VOC may be emitted in many operations for which only particulate factors are given in AP-42. These include alfalfa dehydrating and drying of various grains. Tobacco drying should also

be included in AP-42. Factors for coffee roasting and fish processing are given in terms of specific chemical species and are difficult to transform into total VOC factors. Large amounts of VOC are used as carriers for pesticides, and factors should be derived for pesticide usage preferably by acreage, crop and growing season. VOC emission factors for wine making should be reevaluated to verify that the present listing of "negligible" is accurate.

- Section 7 - Metallurgical Industry

No real deficiencies were identified in this section possibly because no VOC factors are given for any operation other than coke manufacturing. There is a general feeling that VOC may be emitted during secondary smelting, but the amounts are believed to be small. A need was expressed for information on organic species -- particularly benzene -- from byproduct coking.

- Section 8 - Mineral Products Industry

Most operations in this category do not involve VOC emissions except for those associated with fuel combustion to heat kilns and dryers. A question was raised about the inconsistencies in reporting in-process fuel emissions where VOC factors are given for brick manufacturing but not for cement or lime manufacturing. Most users felt that VOC would be emitted from all in-process fuel combustion regardless of the nature of the manufactured products. VOC emissions from coal storage piles were of some concern since there have been reports of 5-percent losses during storage of several months duration.

- Section 9 - Petroleum Industry

Many comments were received about the lack of VOC emission factors for oil and gas production. Specifically, the following operations were mentioned:

Pumps and compressors used in gas processing

Sweetening of natural gas

Dehydration of natural gas

Stationary generators (diesel and gas fueled)

Flares

Steam generators (crude oil fueled)

Seepage from fields

Fugitive emissions at well heads

Suggestions were made that separate factors be developed for onshore and offshore operations and that activities be separated into drilling, production, and processing categories.

Many comments were also received about the VOC factors for refineries. Several individuals questioned the validity of the factors given for fluid coking units, for FCCU's with CO boilers, and the factor designated as miscellaneous (air blowing, sampling, etc.). No factors are listed for oil-water separators, so some users have assumed that these emissions are included in the factor labeled "process drain." Some explanation should be provided. Currently, there is a debate about the appropriateness of basing fugitive emissions estimates on refinery throughput rather than on the number of valves, pump seals, flanges, etc. An attempt should be made to resolve this issue.

- Section 10 - Wood Processing

No comments were recieved concerning this section.

- Section 11 - Miscellaneous Sources

There was little concern about the validity of the VOC factors for forest wildfires and other accidental occurrences because, apparently, little use is made of these factors. There was considerable interest in developing reliable factors for emissions from natural sources such as forests, vegetation, fossil fuel deposits, and quasi-natural sources such as sanitary landfills and cattle feedlots. These natural and quasi-natural emissions are of concern to those who are attempting to predict ambient oxidant levels from precursor levels and, thus, must be concerned with all VOC emissions whether or not they originate from man's activities.

In addition to the specific comments previously listed, AP-42 users made some general comments about the organization and content of the volume. Several users wanted information that would allow them to inventory separately methane, ethane, 1,1,1-trichloroethane, and trichlorotrifluoroethane according to the recommended policy on control of VOC as presented in the July 8, 1977 Federal Register. One agency wanted emission factors for benzene. Several users suggested that a listing of trade names of solvents would be helpful. Some users wanted estimates of uncertainties in emission factors and, in addition, wanted estimates of uncertainties in the overall emissions computation including uncertainties in activity factors as well as emission factors. Several users commented about inconsistencies in factors listed in Appendix C of AP-42 and those listed in the main body of the document.

It is believed that many more deficiencies and inconsistencies would have been identified if it had been possible to interview AP-42 users repeatedly during a prolonged period of using the document. The volume contains too many data items for any individual to recall during one interview. The comments that were received generally dealt with the section of AP-42 that the individual was using at the time of the interview.

In general, users had four reasons for dissatisfaction with the present edition of AP-42.

1. They were attempting to compile an inventory and needed information on a source category that was not listed in AP-42. Examples are tobacco drying, pesticide usage, and combustion of coal/refuse or oil/refuse.
2. They were attempting to evaluate proposals for accomplishing emissions offset, and the proposer had suggested the elimination of emissions from some source such as cutback asphalt paving or vegetation, which was not adequately treated in AP-42.

3. They were not sure that they were correctly interpreting the information given in AP-42. Examples of this are in-process fuel emissions in brick, cement, and lime manufacturing which seem to be inconsistently listed, and evaporative emissions from stationary IC engines which are listed for some engines and not for others. In both instances the users had difficulty in determining whether these emissions had been ignored or whether they, when not listed, were included with other emissions.

4. They were attempting to carry out a new source review and needed to estimate uncontrolled emissions from new equipment. The present edition of AP-42 contains data on existing (or even old) equipment but does not discuss new equipment which may have lower emissions.

No one who was interviewed expected that AP-42 would serve as a primary source of information about control technology and the efficiencies of control devices. Other documents were used as sources of this information. Individuals who were compiling specialized inventories for modeling purposes, also did not expect that AP-42 should provide the information that they require on organic species breakdowns. In fact, such information, if it were included in AP-42 for each source type, would be more detailed than some modelers need or desire. No attempt was made to determine whether these kinds of users would turn to AP-42 as a primary source of information if the necessary data were added to the existing volume.

3.0 ASSIGNMENT OF PRIORITY RATINGS

Volatile organic compound sources were prioritized to select source categories that should be added to AP-42 or most urgently require updating. The first stratification was based on the nationwide annual emissions of VOC from each source category. Additional stratifications were based on the population affected by the source and the number of individual sources.* These factors were compiled for the nation as a whole to give a ranking of sources based on air quality impact. No consideration was given to the reactivity or toxicity of the emitted organics or to the air quality attainment rating in the affected area because it was believed that these factors have little influence on the adequacy of AP-42 as perceived by its users. Computations made by others were used whenever possible because the scope of this study was too limited to permit the compilation of a new data base for nationwide VOC emissions.

The starting point for the prioritization exercise was the priority rating system used by The Research Corporation (TRC) in their analysis of the impact of new source performance standards (NSPS) on emissions from stationary sources.[1] The source classification scheme and emissions calculations were taken from this report and augmented, as necessary, to include other source categories that were identified as being of interest. Selected natural and quasi-natural sources were also added to the listing. The final tabulation of 107 categories is given in Table 3-1. Thirty-two of these categories that emit more than 200×10^6 pounds per year are listed in Table 3-2. Emissions from sources located in rural or unpopulated areas were adjusted by dividing by 500 -- a number chosen to represent the ratio of population densities in

*Higher priorities were given to multiple sources of moderate size than to a single, very large source because it is believed that emissions estimates for the very large source would be based on actual tests rather than emission factors taken from AP-42.

Table 3-1. NATIONAL HYDROCARBON EMISSIONS BY SOURCE CATEGORY

Source Categories	Annual Production	References	Total VOC Emissions Factor	Quality Rating	References	Annual Total VOC Emissions (10^6 lb)	References
I. STATIONARY COMBUSTION SOURCES							
Boilers, fossil fuel						1,008	
<0.3 x 10^6 Btu/hr	7,372 x 10^{12} Btu	1	0.019 lb/10^6Btu	D	1	140	1
0.3-10 x 10^6 Btu/hr	6,618 x 10^{12} Btu		.042 lb/10^6Btu	D	1	278	1
10-250 x 10^6 Btu/hr	6,251 x 10^{12} Btu	1	.045 lb/10^6Btu	D	1	281	1
>250 x 10^6 Btu/hr	16,246 x 10^{12} Btu	1	.019 lb/10^6Btu	D	1	309	1
Boilers, mixed fuel						(.6)	*
Coal and refuse	.12 x 10^6 tons refuse	1	(2 lb/ton refuse)	E	Estimate	(.2)	*
Oil and refuse	.2 x 10^6 tons refuse	1	(2 lb/ton refuse)	E	Estimate	(.4)	*
Boilers, wood waste	94 x 10^6 tons wood waste	1	(5 lb/ton wood)	D	Estimate	(470)	*
Engines, stationary							
Gas turbines						69	
Electric utility	12 x 10^6 hp-yr	1	5.16 lb/hp-yr	B	4	62	1,4
Pipeline	4 x 10^6 hp-yr	1	1.75 lb/hp-yr	A	4	7.0	1,4
Internal combustion						1,265	
Spark ignition	17 x 10^6 hp-yr	1	56 lb/hp-yr	A	1	952	1
Diesel and dual fuel	10 x 10^6 hp-yr	1	31.3 lb/hp-yr	C	1	313	1
Incinerators						84	
Autobody	.3 x 10^6 autos	1	1 lb/auto	C	1	.3	1
Industrial/commercial	12 x 10^6 tons waste	1	2.88 lb/ton	B	1	34	1
Municipal	18 x 10^6 tons waste	1	2.7 lb/ton	B	1	49	1
Pathological	.04 x 10^6 tons waste	1	3.8 lb/ton	C	1	.15	1
Sludge	.6 x 10^6 tons dry feed	1	1.5 lb/ton	B	4	.9	1,4
Conical	Being phased out		15 lb/ton	D	4	-	
Miscellaneous combustion							
Agricultural open burning	280 x 10^6 tons waste	1	20 lb/ton	B	1	5,600	1
	15 x 10^6 tons waste	5	20 lb/ton	B	1	300	5,1
						124	6
Orchard heaters	60 x 10^6 heater hr	1	9.2 lb/heater hr	C	1	552	1
Residential fireplaces	N/A		10 lb/ton	B	4		

Table 3-1. NATIONAL HYDROCARBON EMISSIONS BY SOURCE CATEGORY (CONTINUED)

Source Categories	Annual Production	References	Total VOC Emission Factor	Quality Rating	References	Annual Total VOC Emissions (10^6 lb)	References
II. CHEMICAL PROCESS INDUSTRY							
Acetone	1.0 x 10^6 tons	2	11 lb/ton	C	2	11	2
Acrylic acid	.4 x 10^6 tons	2	174 lb/ton	B	2	70	2
Acrylonitrile	.7 x 10^6 tons	1	330 lb/ton	A	1	231	1
Adhesives manufacture	.06 x 10^6 tons	Estimate	(1,000 lb/ton)	D	Estimate	(60)	Estimate
Adipic acid	.8 x 10^6 tons	1	(40 lb/ton)	D	Estimate	(32)	
Ammonia							
Methanator plant	9 x 10^6 tons	1	90 lb/ton	A	1	810	1
Regenerator and coabsorber	9 x 10^6 tons	1	90 lb/ton	A	1	810	1
Carbon black							
Furnace process	1.5 x 10^6 tons	1	570 lb/ton	B	1	855	1
Charcoal	.7 x 10^6 tons	1	438 lb/ton	C	1	307	1
Detergent	2.25 x 10^6 tons	1	(20 lb/ton)	D	Estimate	(45)	*
DMT/TPA (nitric acid oxidation)	.3 x 10^6 tons	1	63 lb/ton	C	2	19	1,8
Dyes	.1 x 10^6 tons	8	N/A				
Ethylene dichloride (oxychlorination process)	2 x 10^6 tons	1	140 lb/ton	B	1	280	1
Ethylene oxide	1.5 x 10^6 tons	1	392 lb/ton	Unk.	1	588	1
Explosives							
High	1.5 x 10^6 tons	1	N/A				
Low	.4 x 10^6 tons	1	N/A				
Formaldehyde	3 x 10^6 tons	1	27.5 lb/ton	Unk.	1	82.5	1
Fuel conversion-coal gasification							
High Btu gas	Pilot plants only		.003 lb/10^6 Btu		1		
Low Btu gas	Pilot plants only		.001 lb/10^6 Btu		1		
Maleic anhydride (benzene oxidation)	.2 x 10^6 tons	1	172 lb/ton	B	1	34	1
Paint	4 x 10^6 tons	1	30 lb/ton	C	1	120	1
Phthalic anhydride							
Naphthalene	.15 x 10^6 tons	9	103 lb/ton	B	9	15	10
o-xylene	.3 x 10^6 tons	1	130 lb/ton	B	1	39	1
Plastics fabrication and forming	13 x 10^6 tons	10	78 lb/ton	E	10	1,016	10
Printing ink	.3 x 10^6 tons	1	120 lb/ton	E	1	36	1
Soap	.5 x 10^6 tons	1	N/A				
Synthetic fibers						22	
Acetate	.4 x 10^6 tons	1	7 lb/ton	E	1	2.8	1

Table 3-1. NATIONAL HYDROCARBON EMISSIONS BY SOURCE CATEGORY (CONTINUED)

	Source Categories	Annual Production	References	Total VOC Emission Factor	Quality Rating	References	Annual Total VOC Emissions (10^6 lb)	References
II.	CHEMICAL PROCESS INDUSTRY (CONTINUED)							
	Nylon	1.2×10^6 tons	1	7 lb/ton	E	1	8	1
	Polyester	1.6×10^6 tons	1	(7 lb/ton)		Estimate	(11)	*
	Viscose rayon	$.6 \times 10^6$ tons	1	N/A				
	Synthetic resins						393	
	ABS-SAN	$.4 \times 10^6$ tons	1	7.5 lb/ton	B	1	3	1
	Acrylic	$.5 \times 10^6$ tons	1	240 lb/ton	C	1	120	1
	Alkyd	$.36 \times 10^6$ tons	1	1.71 lb/ton	C	1	.6	1
	Phenolic	$.9 \times 10^6$ tons	1	7.5 lb/ton	C	1	6.8	1
	Polyester	$.7 \times 10^6$ tons	1	N/A				
	Polyethylene							
	High density	2×10^6 tons	1	50 lb/ton	B	1	100	1
	Low density	4×10^6 tons	1	25 lb/ton	B	1	100	1
	Polychloroprene	$.5 \times 10^6$ tons	2	13 lb/ton	B	2	6.6	2
	Polypropylene	1.2×10^6 tons	1	.7 lb/ton	B	1	.8	1
	Polystyrene	2×10^6 tons	1	11.7 lb/ton	Unk.	1	23	1
	Polyvinyl chloride	2×10^6 tons	1	17 lb/ton	B	1	34	1
	Urea-melamine	$.6 \times 10^6$ tons	1	7.5 lb/ton	Unk.	1	4.5	1
	Styrene butadiene rubber	1.7×10^6 tons	1	4.2 lb/ton	D	1	7	1
	Varnish	1×10^6 tons	1	68 lb/ton	C	1	68	1
III.	FOOD AND AGRICULTURAL INDUSTRY							
	Agricultural							
	Cotton ginning	10×10^6 bales = 2.4×10^6 tons	1	N/A				
	Pesticides							
	Manufacturing	$.9 \times 10^6$ tons	1	N/A				
	Use	($.9 \times 10^6$ tons)	Estimate	(250 lb/ton including hydrocarbon carrier)	D	Estimate	(225)	*
	Food							
	Animal husbandry (feedlots)	$4{,}615 \times 10^7$ g manure	6	1.6×10^{-3} g/kg manure	C	6	.0002	6
	Beer	5.8×10^9 gal	1	10.9 lb/10^3 gal	Unk.	1	63	1
	Coffee roasting	1.3×10^6 tons roasted	1	1.1 lb/ton	C	1	1.4	1
	Deep fat frying	2×10^6 tons	1	7.75 lb/ton	Unk.	1	15.5	1
	Direct firing of meat	$.02 \times 10^6$ units	1	6,136 lb/unit yr	Unk.	1	123	1
	Feed milling & storage-alfalfa dehydrating	2×10^6 tons	1	(.1 lb/ton)	D	Estimate	(.2)	*

Table 3-1. NATIONAL HYDROCARBON EMISSIONS BY SOURCE CATEGORY (CONTINUED)

Source Categories	Annual Production	References	Total VOC Emission Factor	Quality Rating	References	Annual Total VOC Emissions (10^6 lb)	References
III. FOOD AND AGRICULTURAL INDUSTRY (CONTINUED)							
Food (Cont)							
Fish processing	0.3×10^6 tons fish meal	1	N/A				
Grain handling and processing-drying	39×10^6 tons	1	(.1 lb/ton)	D	Estimate	(4)	*
Meat smokehouses	3×10^6 tons meat	1	.35 lb/ton	D	1	1.05	1
Poultry processing	6×10^6 tons, ready to cook weight	11	(.2 lb/ton)	D	Estimate	(1.2)	*
Rendering	3×10^6 tons	12	N/A				
Starch manufacturing	4×10^6 tons	1	N/A				
Stockyards and slaughterhouses	20×10^6 tons meat	13	N/A				
Sugar cane processing							
Bagasse burning	5×10^6 tons	1	N/A				
Field burning	$.6 \times 10^6$ acres	1	300 lb/acre	Unk.	1	180	1
Vegetable oil manufacturing	6×10^6 tons	1	38 lb/ton	Unk.	1	228	1
Whiskey processing	1×10^9 gal	1	2.76 lb/10^3 gal	Unk.	1	3	1
Wine processing	$.4 \times 10^9$ gal	14	(10 lb/10^3 gal)	Unk.	Estimate	(4)	*
Other							
Pharmaceuticals	$.2 \times 10^6$ tons	1	N/A				
Tanneries	22×10^6 equivalent cattlehides	14	N/A				
IV. MINERAL PRODUCTS INDUSTRY						198	
Asphalt						116	1
Batching	696×10^6 tons	1	.167 lb/ton	Unk.	1	75	6
Pavement	22×10^6 tons	15	None used-see Ref. 6 for method	C	6		
Roofing						7	1
Blowing	2.79×10^6 tons	1	2.5 lb/ton	D	1		
Saturator	5.7×10^6 tons	1	N/A				
Concrete, cement plants	93×10^6 tons	1	N/A				
Processing						2	1
Brick and related clay products	29×10^6 tons	1	.073 lb/ton	C	1		
Calcium carbide	$.2 \times 10^6$ tons	16	18 lb/ton	C	4	3.6	4,16

Table 3-1. NATIONAL HYDROCARBON EMISSIONS BY SOURCE CATEGORY (CONTINUED)

Source Categories	Annual Production	References	Total VOC Emission Factor	Quality Rating	References	Annual Total VOC Emissions (10^6 lb)	References
IV. MINERAL PRODUCTS INDUSTRY (CONT)							
Processing (Continued)							
Castable refractory	0.3 x 10^6 tons	1	N/A				
Ceramic clay	11 x 10^6 tons	1	N/A				
Clay and flyash sintering							
Clay	.56 x 10^6 tons	1	N/A				
Flyash	6.62 x 10^6 tons	1	N/A				
Coal cleaning (thermal drying)	78 x 10^6 tons	1	N/A				
Coal refuse piles, etc.	275 x 10^6 tons burning material	20	1.6x15^{-6} lb/hr ton	Unk.	20	.7	20
Fiberglass							
Wool processing	.8 x 10^6 tons	1	3.39 lb/ton	Unk.	1	2.7	1
Textile processing	.35 x 10^6 tons glass	1	N/A				
Frit	.67 x 10^6 tons	1	N/A				
Glass							
Soda lime glass	28 x 10^6 tons	1	.08 lb/ton	C	21	2.2	21
Opal glass	.4 x 10^6 tons	1	N/A				
Mineral wool	7 x 10^6 tons	1	2 lb/ton		1	14	1
V. METALLURGICAL INDUSTRY							
Primary Iron and Steel							
Coke ovens						330	
Beehive oven	.7 x 10^6 tons	17	8	C	4	5.6	4,17
Byproduct oven	55 x 10^6 tons	1	5.9 lb/ton	C	1	324	1
Sinter plant	60 x 10^6 tons	22	4 lb/ton sinter	B	22	240	*
Secondary metals							
Aluminum							
Sweat furnace	1 x 10^6 tons	1	N/A				
Reverb furnace	.2 x 10^6 tons	1	N/A				
Brass and bronze smelting	.3 x 10^6 tons	1	N/A				
Cast iron foundry							
Core ovens	19 x 10^6 tons	1	10.5 lb/ton	Unk.	1	200	1
Cupola furnace	N/A		N/A				
Electric furnace	7.53 x 10^6 tons	1	N/A				
Copper smelting and refining	1.5 x 10^6 tons	1	N/A				

Table 3-1. NATIONAL HYDROCARBON EMISSIONS BY SOURCE CATEGORY (CONTINUED)

Source Categories	Annual Production	Refereoces	Total VOC Emission Factor	Quality Rating	References	Annual Total VOC Emissions (10^6 lb)	References
V. METALLURGICAL INDUSTRY (CONTINUED)							
Lead smelting							
Blast furnace	0.1 x 10^6 tons	1	N/A				
Pot furnace	.04 x 10^6 tons	1	N/A				
Reverb furnace	.5 x 10^6 tons	1	N/A				
Magnesium smelting	.01 x 10^6 tons	1	3.39 lb/ton	Unk.	1	.03	1
Steel foundries	26.4 x 10^6 tons	1	N/A				
Zinc							
Distillation	.3 x 10^6 tons	1	N/A				
Sweat furnace	.2 x 10^6 tons	1	N/A				
VI. EVAPORATION LOSS SOURCES							
Degreasing	1,333 x 10^6 tons metal cleaned	1	1.5 lb/ton	E	1	2,000	1
Drycleaning	2.4 x 10^6 tons clothes	1	258 lb/ton	B	1	619	1
Graphic arts						936	
Gravure	.1 x 10^6 tons ink	1	2,300 lb/ton ink	E	1	230	1
Flexography	.05 x 10^6 tons ink	1	4,800 lb/ton ink	E	1	240	1
Lithography	.06 x 10^6 tons ink	1	2,800 lb/ton ink	E	1	168	1
Letter press	.1 x 10^6 tons ink	1	1,500 lb/ton ink	E	1	150	1
Metal decorating	.04 x 10^6 tons ink	1	3,700 lb/ton ink	E	1	148	1
Petroleum storage and transfer							
Nonpipeline transfer						277	
Aviation gas	30.6 x 10^6 bbl	1	.116 lb/bbl	A	1	4	1
Crude oil	1,224 x 10^6 bbl	1	.084 lb/bbl	A	1	103	1
Gasoline	1,326 x 10^6 bbl	1	.116 lb/bbl	A	1	154	1
Jet fuel	124 x 10^6 bbl	1	.116 lb/bbl	A	1	14	1
Special naphtha	153 x 10^6 bbl	1	.116 lb/bbl	A	1	1.8	1
Refueling motor vehicles	2,533 x 10^6 bbl	1	.504 x lb/bbl	B	1	1,277	1
Service stations	2,508 x 10^6 bbl	1	.38 lb/bbl	A	1	953	1
Tank storage						4,573	
Aviation gas - breathing	37 x 10^6 bbl	1	2.85 lb/bbl	B	1	105	1
- working	57 x 10^6 bbl	1	.116 lb/bbl	B	1	7	1
Crude oil - breathing	589 x 10^6 bbl	1	2.88 lb/bbl	B	1	1,696	1
- working	5,100 x 10^6 bbl	1	.085 lb/bbl	B	1	434	1
Distillate - breathing	643 x 10^6 bbl	1	.593 lb/bbl	B	1	381	1

Table 3-1. NATIONAL HYDROCARBON EMISSIONS BY SOURCE CATEGORY (CONTINUED)

Source Categories	Annual Production	References	Total VOC Emission Factor	Quality Rating	References	Annual Total VOC Emissions (10^6 lb)	References
VI. EVAPORATION LOSS SOURCES (CONTINUED)							
Tank Storage (Continued)							
Gasoline - breathing	477 x 10^6 bbl	1	2.85 lb/bbl	B	1	1,359	1
- working	2,508 x 10^6 bbl	1	.116 lb/bbl	B	1	291	1
Jet fuel - breathing	124 x 10^6 bbl	1	1.4 lb/bbl	B	1	174	1
- working	235 x 10^6 bbl	1	.116 lb/bbl	B	1	27	1
Kerosene - breathing	76 x 10^6 bbl	1	.593 lb/bbl	B	1	45	1
Special naphtha - breathing	18 x 10^6 bbl	1	2.85 lb/bbl	B	1	51	1
- working	28 x 10^6 bbl	1	.116 lb/bbl	B	1	3	1
Surface coating							
Industrial	711 x 10^6 gal	1	6.55 lb/gal	B	1	4,657	1
Domestic	218 x 10^6 gal	12	.8 lb/gal	B	1	180	*
Textile processing						12	
Heat settling and finishing	.7 x 10^6 tons textiles	1	10.18 lb/ton	Unk.	1	7	1
Texturizing	.8 x 10^6 tons textiles	1	4.6 lb/ton	Unk.	1	3.7	1
Carpet manufacturing	1.55 x 10^6 tons textiles	1	.8 lb/ton	Unk.	1	1.2	1
VII. PETROLEUM INDUSTRY							
Refining						3,125	
FCCU	1,280 x 10^6 bbl	1	220 lb/10^3 bbl	B	4	282	1,4
TCCU and HCCU	199 x 10^6 bbl	1	87 lb/10^3 bbl	B	4	174	1,4
Process gas combustion	.17 x 10^{12} cu.ft.	1	33 lb/10^6 cu.ft.	B	1	5.6	1
Vacuum distillation	1,569 x 10^6 bbl	1	.13 lb/bbl	B	1	204	1
Misc. point sources	4,196 x 10^6 bbl	1	.586 lb/bbl	B	1	2,459	1
Oil and gas production							
Crude oil						(7,900)	
Onshore	100 x 10^9 bbl	7	(40 lb/10^3 bbl)	C	Estimate	(4,000)	*
Offshore	6 x 10^9 bbl	7	(20 lb/10^3 bbl)	C	Estimate	(120)	*
Natural gas	21.6 x 10^{12} cu.ft.	7	(175 lb/10^6 cu.ft)	C	Estimate	(3,780)	*
VIII. WOOD PRODUCTS INDUSTRY							
Wood drying	33 x 10^9 board feet	18	N/A				
Wood processing						25	
Pulpboard	36 x 10^6 tons	1	(.1 lb/ton)	D	Estimate	(3.6)	*

Table 3-1. NATIONAL HYDROCARBON EMISSIONS BY SOURCE CATEGORY (CONCLUDED)

Source Categories	Annual Production	References	Total VOC Emission Factor	Quality Rating	References	Annual Total VOC Emissions (10^6 lb)	References
VIII. WOOD PRODUCTS INDUSTRY (CONTINUED)							
Plywood	21.5×10^9 sq.ft.	1	0.001 lb/sq.ft.	B	1	21.5	1
Wood pulping, kraft process (sulfate)	33×10^6 tons	1	4.69 lb/ton	B	1	155	1
IX. ASSEMBLY PLANTS							
Cable cover production	$.4 \times 10^6$ tons lead	7	N/A				
Lead acid batteries	61×10^6 batteries	1	.009 lb/battery	Unk.	1	.55	1
Type metal production	$.02 \times 10^6$ tons lead	7	N/A				
X. WASTE DISPOSAL (NONCOMBUSTION)							
Sanitary landfill	163×10^3 acres		N/A				
Sewage treatment	58×10^{11} gal	6	.7 lb/10^6 gal	D	6	4	6
XI. OTHER							
Leakage from natural gas systems	19.1×10^{12} cu.ft.	7	126 lb/10^6 cu.ft. nonmethane HC	C	19	2,400 nonmethane HC	19
Natural and quasi-natural sources							
Managed burns	154×10^8 kg burned/yr	6	5.4 g/kg	C	6	184	6
Grasslands	244×10^6 kg		2.3 g/kg-yr	C	6	12,386	6
Forest fires	340×10^8 kg burned/yr	6	10.3 g/kg	C	6	772	6
Softwood forests	328×10^{10} kg	6	11.8 g/kg-yr	B	6	84,920	6
Hardwood forests	97×10^{10} kg	6	5.9 g/kg-yr	B	6	12,628	6

( ) Indicates quantities estimated by PES
* Computed by multiplying columns 2 and 4

urban and rural areas. These adjusted emissions are also listed in Table 3-2. Additional adjustments were made in certain source categories as follows:

1. Ammonia manufacture was deleted from the list because the hydrocarbon emissions consist entirely of methane and also because an AP-42 section will be prepared by the Monsanto Research Corporation under contract to EPA.
2. Acrylonitrile and carbon black were deleted from the list because AP-42 sections for these sources will be prepared by Monsanto Research Corporation under contract to EPA.
3. Ethylene oxide and ethylene dichloride were flagged to indicate that their priority rating should be lowered because of a relatively small number of sources -- 16 for ethylene dichloride[2] and a similar (but uncertain) number for ethylene oxide.

This final adjusted listing of source categories in given in Table 3-3 prioritized according to air quality impact as determined by total VOC emissions. Sources that emit primarily methane are listed according to their emissions of VOC other than methane. Sources were also rated according to (1) quality and applicability of existing emission factors, (2) needs as perceived by users, and (3) work underway or recently completed that could lead to new or improved emission factors. These factors were combined with the air quality impact ranking to give a final priority ranking as shown in Table 3-3. Source categories of lesser air quality impact than those listed in Table 3-3 were evaluated similarly but in a qualitative rather than a formal quantitative manner. This is discussed further in Section 4.0 as part of the explanation of the work plan.

Table 3-2. VOC SOURCE CATEGORIES WITH TOTAL ANNUAL EMISSIONS GREATER THAN 200 x 10^6 POUNDS

Source Categories	Annual Emissions (10^6 lb)	Annual Emissions Adjusted for Population Exposed[a] (10^6 lb)
Softwood forests	24,920	598
Hardwood forests	12,628	253
Grasslands	12,386	248
Oil and gas production (oil, 4,100; gas, 3,800)	7,900	7,900
Agricultural open burning	5,600[b]	112
Industrial surface coating (sheet, strip, and coil, 1,723; paper and paperboard, 1,723; fabric treatment, 699; automobile and truck finishing, 373; miscellaneous, 139)	4,657	4,657
Petroleum tank storage	4,573	4,573
Petroleum refining	3,125	3,125
Leakage from gas distribution	2,400[c]	2,400[c]
Degreasing	2,000	2,000
Ammonia manufacture	1,620	1,620
Refueling motor vehicles	1,277	1,277
Stationary internal combustion engines	1,265	1,265
Plastics fabrication and forming	1,016	1,016
Boilers, fossil fuel	1,008	1,008
Gasoline service stations	953	953
Graphic arts	936	936
Carbon black, furnace process	855	855
Forest fires	772	2
Drycleaning	619	619
Ethylene oxide manufacture	588	588
Orchard heaters	552	1
Woodwaste boilers	470	1
Synthetic resin manufacture	393	393
Byproduct coke ovens	324	324
Charcoal manufacture	307	307
Ethylene dichloride manufacture	280	280
Nonpipeline transfer of petroleum	277	277
Acrylonitrile manufacture	231	231
Vegetable oil manufacture	228	228
Pesticide usage	225	1

[a] See text, pages 3-1 and 3-10, for explanation.

[b] Another source (Ref. 5) gives 300 x 10^6 lb/yr as an emissions estimate.

[c] Does not include methane.

Table 3-3. VOC SOURCE CATEGORIES ARRANGED IN ORDER OF AIR QUALITY IMPACT

Source Categories	Annual Emissions Adjusted for Population (10^6 lb)	Rank	Deficiencies in AP-42[a]	Need as Perceived by Users[a]	Work Underway or Completed[a]	Overall Data Parameter (Sum) of Previous 3 Columns)	Overall Priority	Final Priority Ranking
Oil and gas production	7,900	1	2	1	1	4	4	1
Industrial surface coating	4,657	2	3	2	2	7	14	2
Petroleum tank storage	4,573	3	3	1	1	5	15	3
Petroleum refining	3,125	4	1	1	1	5	20	4
Leakage from gas distribution	2,400[b]	5	1	3	4	8	40	6
Degreasing	2,000	6	1	3	2	6	36	5
Refueling motor vehicles	1,277	7	3	4	2	9	63	8.5
Stationary internal combustion engines	1,265	8	3	2	3	9	72	10
Plastics fabrication and forming	1,016	9	2	3	2	7	63	8.5
Boilers, fossil fuel	1,008	10	3	2	1	6	60	7
Gasoline service stations	953	11	3	4	2	9	99	12
Graphic arts	936	12	1	3	3	7	84	11
Drycleaning	619	13	3	3	4	10	130	17
Ethylene oxide manufacture[b]	588	14	1	4	4	9	126	15.5[c]
Synthetic resin manufacture	393	15	2	4	2	8	120	14
Byproduct coke ovens	324	16	2	2	2	6	96	13
Charcoal manufacture	307	17	2	4	2	8	136	19
Ethylene dichloride manufacture[b]	280	18	1	4	2	7	126	15.5[c]
Nonpipeline transfer of petroleum	277	19	4	1	2	7	133	18
Vegetable oil manufacture	228	20	1	4	4	9	180	20

[a] 1 = greatest extent. 4 = least extent.

[b] Does not include methane.

[c] Lower priority because of small number of individual sources.

The highest priority source categories for revised AP-42 sections were found to be:

Oil and gas production
Industrial surface coating
Petroleum tank storage
Petroleum refining

For these sources the final priority rankings were identical to the rankings based on air quality impact alone. Industrial surface coating receives a high priority ranking because the diverse operations in this category are considered collectively rather than individually. Prioritization of 268 individual surface coating operations has been performed by the Monsanto Research Corporation[3] so it is possible to consider individual subcategories, if desired, in formulating a plan to update AP-42.

The final priority ratings from Table 3-3 are used in the organization of Section 4.0 which summarizes work recently completed or underway and in the formulation of the workplan that is presented in Section 6.0. The availability of information on reactive and nonreactive VOC is discussed in Section 4.0, but was not considered explicitly in deriving priority ratings.

4.0 ACCOMPLISHED AND CURRENT RESEARCH

Research that has recently been accomplished or is currently underway that could lead to new and improved emission factors is summarized in Paragraphs 4.1 through 4.19 for each of the highest priority source categories. A more complete listing that includes all source categories is given in Appendix B.

4.1 OIL AND GAS PRODUCTION

In general, no comprehensive field studies have been completed to provide a data base for formulating emission factors. Emission factors have been developed by extrapolation of factors developed for similar source categories, such as petroleum refining and stationary internal combustion. Field studies are underway that relate specifically to oil and gas production.

- "Atmospheric Emissions From Offshore Oil and Gas Development," EPA-450/3-77-026, June 1977. A report prepared by Energy Resources Company, Inc., for EPA under Contract No. 68-02-2512.

  This report includes no field studies, but it contains suggested emission factors developed from existing literature. It presents detailed process descriptions including drilling, oil and gas processing, and waste treating, and identifies emission sources which require further study -- specifically gas vents, oil storage vents, water separators, compressor seals and thrust bearing vents and well completion, blowouts, and oil spills. Qualitative comments are made about the relative amounts of methane and total hydrocarbons.

- "Control of Hydrocarbon Emissions From Stationary Sources in the South Coast Air Basin." A report prepared for the California Air Resources Board by KVB, Inc., which is to be issued in draft form in January 1978, and in final form later in the spring.

  This report includes field testing of 54 sources at two oil fields in the Los Angeles area. Detailed hydrocarbon species analysis were performed by gas chromatography-mass spectrometry (GC-mass spec.) techniques. Since the purpose of the study was to develop an emission inventory rather than to formulate emission factors, no detailed

descriptions of the oil field operations are included. Detailed test results may not be included in the study report but will be available from a data tape that will be submitted to the California Air Resources Board with the report.

- "Multimedia Assessment of Environmental Effect of Natural Gas Processing Plants." A study in progress by TRC for the Chemical Processes Branch of IERL and scheduled to be completed in the spring of 1978.

  This work does not involve any field testing, but it will provide a summary of the state of knowledge with particular emphasis on reactive organics.

- "Evaluations of Emissions From Onshore Drilling, Producing, and Storing of Oil and Gas." A study in progress by PES for the Chemicals and Petroleum Branch, ESED, OAQPS, to be completed by the summer of 1978.

  This study will not include field testing, but it will provide detailed descriptions of process operations and sources of emissions. The best possible emissions factors will be derived from existing literature. Representative oil fields from the entire United States will be studied.

- "Fugitive Emissions From Oil Field Producing Operations." A study in progress by Rockwell International for the American Petroleum Institute. Draft report to be submitted in July 1978, and final report issued later in 1978.

  This is expected to provide the definitive data base for evaluating emissions from oil and gas production. The field tests have been designed to provide statistically valid data for onshore and offshore production in the major United States producing areas. Fixed roof storage tanks are included in the study. Hydrocarbons will be analyzed by gas chromatography to provide a species breakdown.

- "Determination of Air Pollutant Emission Factors for Thermal Tertiary Oil Recovery Operations in California." A study to be conducted by KVB, Inc., for the California Air Resources Board. Probable issue date is the spring of 1979.

This study will include assembly of all existing information on tertiary recovery steam generators (36 known tests) and development of emission factors if existing test data are sufficient; otherwise, field tests will be done to fill data gaps. Tests will be conducted to measure fugitive emissions, and hydrocarbon species will be measured by GC-mass spec. analysis for all tests performed by the contractor.

- "Natural Gas and Crude Oil Production." A document bearing this title is proposed for the series of Control Technology Documents for Stationary Sources of VOC.

  There is no scheduled date for issuing this document. Apparently there is no firm assurance that it will be issued.

- Miscellaneous unpublished tests conducted by the California Air Resources Board and local California agencies, tests conducted by oil producing companies and reported in environmental impact reports (EIR's) or permit applications, and miscellaneous tests conducted by EPA. No attempt was made to collect detailed information about these because source test results usually do not contain any breakdown of gaseous hydrocarbon species, although some tests may include measurements of condensible hydrocarbons.* Source test results are not usually accompanied by sufficient information to characterize the activity level of the source (production rates, fuel consumption, rates, etc.), and unless this information can be obtained independently, the test data are not useful in the development of emission factors. In the particular case of oil and gas production, where well-planned studies are in progress for the purpose of developing emission factors, it is believed that collection of a number of miscellaneous test results would not be useful enough to justify the effort.

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*This term is commonly used to mean organic materials that are trapped in an impinger and subsequently recovered by extraction with chloroform or other organic solvent.

4.2 INDUSTRIAL SURFACE COATING

The existing Section 4.2-1 of AP-42 does not meet the needs of users primarily because it does not describe the types of data that should be gathered to define the level of activity for these operations and does not deal with the problems of handling the multiplicity of trade names that are applied to solvents. These needs can be met by organizing and summarizing existing material; field testing is not required except possibly in instances where sufficient heat is applied to cause changes in the chemical composition of the solvent. Most of the relevant research summarized herein deals with the organization of material on surface coating rather than field testing.

- "Source Assessment: Prioritization of Air Pollution From Industrial Surface Coating Operations," EPA-650/2-75-019-a, February 1975. A report prepared by Monsanto Research Corporation for EPA under Contract No. 68-02-1320.

  The report prioritizes surface coating operations according to type of product coated -- 268 in all. Solvent composition, surface area of each unit coated, and coverage per unit volume of coating material are listed for each type of product. Priority lists were generated according to four options: (1) toxicity of emitted organic species, (2) toxicity of photochemical oxidant, (3) worst-case toxicity, and (4) total mass of organic emissions.

- "Control Technology Guidance Documents for Stationary Sources of Volatile Organic Compounds, Vol. 1, General; Coil, Paper and Fabric Products; Vol. III, Surface Coating of Metal Furniture; Vol. IV, Surface Coating for Insulation of Magnet Wire; Vol. V, Large Appliance Manufacture." OAQPS Guideline Series published in December 1977 (some volumes issued earlier).

  These documents emphasize control technology and, as a rule, do not include any results of field tests unless they were done to evaluate control devices. They contain no detailed information on chemical composition of coatings or solvents, but they do include useful process descriptions.

- "Control Technology Guidance Documents for Stationary Sources of Volatile Organic Compounds; Surface Coating

of Other Metal Products - Industrial; Flat Wood Products." OAQPS Guideline Series scheduled for publication in June 1978.

The format and content of these is expected to be similar to other volumes in this series and emphasize control technology rather than emission factors.

- "Control Technology Guidance Documents for Stationary Sources of Volatile Organic Compounds; Wood Furniture Manufacture; Architectural and Miscellaneous Coatings." OAQPS Guideline Series scheduled for publication in December 1978.

  These documents are expected to be similar to others in the series. It is not known whether the wood furniture document will emphasize surface coating, but it is assumed that it will because the process has not been treated in other volumes in the series.

- "Control Technology Guidance Documents for Stationary Sources of Volatile Organic Compounds; Other Industrial Surface Coatings; Auto Refinishing; Other Solvent Usage." OAQPS Guideline Series that are listed without any proposed date of issuance.

  No comments can be made about the contents of these documents at this time. Apparently, there is no certainty that they will ever actually be issued.

- "Control of Hydrocarbon Emissions From Stationary Sources in the South Coast Air Basin." Report prepared by KVB, Inc., for the California Air Resources Board -- to be issued in draft form in January 1978, and in final form later in the spring.

  Fifty field tests were performed on various kinds of surface coating operatings. Detailed hydrocarbon species analyses were performed by GC-mass spec., but no detailed descriptions of the processes are given since the purpose of the study was to compile an inventory rather than to develop emission factors.

- "Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds," EPA-450/2-77-028, December 1977.

  This report describes the information that should be collected as part of an emission inventory that includes surface coating operations. It gives guidance on using this information to calculate emissions.

4.3 PETROLEUM TANK STORAGE

The existing section in AP-42 was revised in April 1977, and might be expected to contain very recent test data; however, this is not the case. The section is based on information contained in bulletins issued by the American Petroleum Institute between 1959 and 1969. Many users of AP-42 believe that this information is outdated. Work is in progress to remedy this situation.

- "Floating Roof Emission Test Program Report," prepared by Chicago Bridge and Iron for Standard Oil of Ohio, November 18, 1976.

  Studies were conducted on 8- and 20-foot-diameter scale model tanks. The following variables were studied: (1) organic liquid vapor pressure and temperature, (2) seal type, (3) secondary seal, and (4) gap size and location. No field tests were done, and an octaine-propane blend was used as a surrogate for petroleum distillate. Total hydrocarbons were measured with a flame ionization detector.

- "Metallic Seating Ring Emission Test Program Report," prepared by Chicago Bridge and Iron for the Western Oil and Gas Association, January 19, 1977.

  Studies were conducted on 8- and 20-foot-diameter scale model tanks. Evaluations included the effects of wind sweeping hydrocarbon gases out of the vapor space and into the atmosphere. The quality of ring installation, gap sizes and locations, and secondary seals were varied systematically as part of the experimental design. Total hydrocarbons were measured with a flame ionization detector.

- "Hydrocarbon Emissions From Floating Roof Petroleum Tanks." Report prepared by Engineering Science, Inc., for the Western Oil and Gas Association, January 19, 1977.

  Field tests were conducted to measure evaporative losses for 13 tanks storing petroleum distillate and three tanks storing crude oil. Emissions were evaluated indirectly by measuring the change in the density of the stored liquid. The program was hampered by numerous experimental difficulties, but a workable test procedure was finally devised.

- "Floating Roof Tank Evaporative Loss Study." Statement by the Mobil Oil Corporation, Princeton, N.J., to the California Air Resources Board Workshop, December 17, 1976.

  This study, which is still in progress, involves a 4,000 gallon square test tank. The effects of wind speed, temperature, vapor pressure, and various seal combinations are being evaluated.

- "Hydrocarbon Emissions From Fixed Roof Petroleum Tanks." A report prepared by Engineering Science, Inc., for the Western Oil and Gas Association, July 1977.

  This study included 46 tanks ranging in size from less than 2,000 barrels to more than 100,000 barrels which were used to store crude oil (37 tanks), distillate (six tanks), and fuel oil (three tanks). Measured emissions were compared with those calculated from API Bulletin 2518, and differences were found. Hydrocarbon species were measured and are reported according to molecular weight categories.

- "Petroleum Liquid Storage, Fixed Roof Tanks." OAQPS Guideline Series published in December 1977.

  This report contains no original test data but does summarize some interim results from studies in progres.

- "Petroleum Liquid Storage, Floating Roof Tanks." OAQPS Guideline Series scheduled for publication in June 1978.

  This report is expected to contain summaries of data from other studies but will not include original test data.

- "Floating Roof Tank Emission Study." A study in progress by Engineering Science, Inc., for the American Petroleum Institute. Report is due in the spring of 1979.

  This study will provide field test data that will serve as a basis for updating and revising API Bulletins 2517 and 2519.

- "Control of Hydrocarbon Emissions From Stationary Sources in the South Coast Air Basin." Report prepared by KVB, Inc., for the California Air Resources Board -- to be issued in draft form in January 1978, and in final form later in the spring.

  Field tests were performed on three oil field tanks (with vapor recovery systems) and on seven refinery tanks. Detailed hydrocarbon species analyses were performed by GC-mass spec., but no detailed descriptions of the tanks are given since the purpose of the study was to compile an inventory rather than to develop emission factors.

4.4 PETROLEUM REFINING

The present information in AP-42 on petroleum refining is derived almost entirely from a study conducted by the Los Angeles County Air Pollution Control District in the late 1950's. This study was extensive and used the most advanced techniques that were available at that time; however, many users of AP-42 feel that it is no long adequate. Work is presently underway to provide an updated data base.

- "Development of Improved Emission Factors and Process Descriptions for Petroleum Refining." Report prepared for EPA by Radian Corporation under Contract No. 68-02-1886, April 15, 1977.

  The contract did not include any field testing. The report is a corrected version of the material in AP-42 with some improvements in stationary source factors. As a part of the contract, the material is written in a format suitable for inclusion in AP-42, and will be included in a forthcoming AP-42 supplement.

- "Assessment of the Environmental Emissions From Oil Refining." A study in progress by Radian Corporation for the Chemical Processes Branch of IERL and scheduled for completion in the spring of 1979.

  This includes sampling for hydrocarbons at fugitive and point emission sources at 14 refineries. No emissions from storage are included. One of the purposes of this contract is to provide improved emission factors for petroleum refineries accompanied by information on the distribution of hydrocarbon species in the various emissions. Suitable sections in AP-42 format are expected to be included with the final report.

- "Control of Hydrocarbon Emissions From Stationary Sources in the South Coast Basins." Report prepared for the California Air Resources Board by KVB, Inc., which is to be issued in draft form in January 1978, and in final form later in the spring.

  This report includes results of 66 field tests at three refineries in the Los Angeles area. Stationary and fugitive sources are included, and storage tanks were tested at two of the refineries. Detailed hydrocarbon species

analyses were performed by GC-mass spec. techniques. Since the purpose of this study was to develop an emission inventory rather than to formulate emission factors, no detailed descriptions of refinery operations are included. Detailed results of all the tests may not be contained in the study report but will be available from a data tape that will be submitted to the California Air Resources Board with the report.

- "Survey of Compliance Analysis and Study of Air Pollution Problems and Controls at Petroleum Refineries." Report prepared for EPA by PES under Contract No. 68-02-1378, April 1977.

  This study was a compliance evaluation of every refinery in the United States. One result of this evaluation was the compilation of a comprehensive file of refinery source tests, believed to include most of the tests ever performed on all refineries in the United States. Normally, source test reports include so little process information that they are not well-suited for emission factor development; however, since these test results are already compiled, it might be worthwhile to scrutinize them to see if any useful conclusions can be drawn relative to emission factors.

- "Petroleum Refinery Vacuum Systems, Waste Water Separators and Process Unit Turnaround." OAQPS Guideline Series published in October 1977.

  This document includes summaries of existing data that relate to control technology. No original test results are presented.

- "Petroleum Refinery Fugitive Emissions (Leaks)." OAQPS Guideline Series scheduled for publication in June 1978.

  This document is expected to emphasize control technology rather than the estimation of emissions from leakage.

4.5 DEGREASING

There is no section in the present edition of AP-42 that is devoted to degreasing. The situation is similar to that previously discussed for industrial surface coating; organization of data is required rather than field testing because, in this operation, the solvent consumed essentially equals the solvent emitted to the atmosphere. Two reports have been published and may be helpful organizing this material.

- "Source Assessment: Solvent Evaporation-Degreasing," EPA-600/2-76-032d, June 1976. A report prepared by Monsanto Research Corporation for EPA under Contract No. 68-02-1874.

  This report describes various kinds of degreasing processes and lists the number of plants of each type. Emissions are estimated for the entire United States by defining a representative source for each solvent type based on information contained in the NEDS data base. Emission factors of 1,000 grams per kilogram are applied to solvent consumption data for the entire nation. No information is presented that can be used to relate solvent consumption to the amount of material cleaned or degreased. Some of the material in this report would be useful for AP-42, but, it does not address the problem of estimating emissions from a single plant or even a single urban area.

- "Control of Volatile Organic Emissions From Solvent Metal Cleaning," EPA-450/2-77-022. OAQPS Guideline Series published in October 1977.

  This report deals primarily with the performance of controls, but a few tests of uncontrolled units are included. Emphasis is placed on estimated average, nationwide emissions rather than evaluating single degreasing units.

4.6 LEAKAGE FROM GAS DISTRIBUTION

This source has been identified as a major one in the Los Angeles area by using specialized analytical techniques that have not been implemented elsewhere. The basic technique is described in the publication discussed herein.

- "Source Reconciliation of Atmospheric Hydrocarbons." This report, dated March 1975, was prepared by Henry Mayrsohn and James Crabtree of the California Air Resources Board Laboratory, El Monte, California.

  The source recondiliation technique involves measurement of atmosphere C_2 - C_5 hydrocarbons and developing profiles for various locations, times of day, and seasons. Source profiles were determined for major sources of atmospheric hydrocarbons in the Los Angeles area, including automotive exhaust, gasoline, gasoline vapor, commercial natural gas, geogenic natural gas, and liquefied petroleum gas. Multi-

variate regression analysis was used to determine the contribution of each source category to the atmospheric mix.

The contribution of each category varies with location and time of day, but the average distribution of nonmethane hydrocarbon emissions was found to be automotive exhaust, 47 percent; gasoline, 31 percent; commercial natural gas, 8 percent; geogenic natural gas, 14 percent; and liquefied petroleum gas, 1 percent. Commercial natural gas in the Los Angeles area contained 83-percent methane, 11-percent ethane, and 6-percent higher hydrocarbons.

Based on the aforementioned Los Angeles data, the quantity of nonmethane hydrocarbons from commercial natural gas is 8 percent of the total 720,000 tons per year of organic emissions in the South Coast Air Shed or 115×10^6 pounds per year. This is approximately 0.3 percent of all gas distributed to customers. Assuming that emissions are proportional to quantities of natural gas delivered to the customer, we can calculate that nationally the nonmethane hydrocarbons from this source are $2,400 \times 10^6$ pounds per year, which can be broken down into $1,600 \times 10^6$ pounds per year of ethane and 800×10^6 pounds per year of higher hydrocarbons. No similar studies have been conducted in other geographic areas, so it is impossible to tell whether the Los Angeles results are typical. Possibly source reconciliation studies may be carried out as part of the Tulsa Field Study. According to the Project Officer, Norman Possiel of AMTD, a decision will be made by June 1978, whether source reconciliation will be attempted. If so, they plan to use the same source categories that were developed for Los Angeles and thus might obtain results that could be compared with the Los Angeles results. It is reasonable to assume that many leaks exist in natural gas distribution systems, and it is important to realize that reactive organics from this source may contribute appreciably to the total reactive organics burden.

4.7 BOILERS, FOSSIL FUEL

Until recently there was little concern about hydrocarbon emission factors for boilers because VOC emissions were thought to be small and unimportant. There is now a growing realization that large boilers may emit appreciable amounts of VOC. The current state of knowledge has been summarized recently in several internal EPA documents.

- "Appropriate NMVOC Emission Factors for Use in Evaluating Offset Emissions From New Powerplants and Incinerators." Memo dated June 3, 1977, from Robert E. Neligan, Director MDAD to William S. Baker, Chief of the Air Branch of EPA Region IX.

  This memo includes four enclosures that summarize the data on which the present AP-42 factors are based. The need for additional systematic comprehensive work is pointed out.

- "Organic Emissions From Conventional Stationary Combustion Sources," Smith, N.D. An internal report prepared in August 1977 by IERL's Special Studies Staff.

  This report summarizes all published tests on organic emissions from conventional boilers. Emissions are reported as total hydrocarbons (HC), benzene soluble organics (BSO), and benzo(a)pyrene (BaP). The author concludes that "What emerges from this compilation is that our present knowledge of organic pollutants in the flue gas of conventional stationary combustion sources is very incomplete. It is clear that most of the data compiled here already existed 10 or 15 years ago. While these early results may still provide a good comparison of emissions from several diverse sources, the individual values must now be held suspect in view of recent improvements in emission control devices and sampling-analysis methods."

- "Data on Organic Emissions From Combustion Equipment." Memo dated October 7, 1977, from Wade H. Ponder, Manager Combustion Pollution Assessment Program/IERL to Robert T. Walsh, Chief, Chemical and Petroleum Branch.

  This memo summarizes work that is in progress that will provide information on organic emissions from combustion sources. The relevant individual projects are discussed herein.

- "Combustion Studies" in progress by Exxon for the Combustion Research Branch of IERL-RTP.

  Test data for three coal-fired utility boilers -- including gaseous hydrocarbon measurements -- are scheduled to be reported to CRB/IERL around December 1977.

- "Environmental Assessment of Stationary Source NO_x Control Technologies." Work in progress by Aerotherm under a 3-year contract to the Combustion Research Branch of IERL-RTP. Field testing is scheduled to continue through the summer of 1978.

  Some data on volatile organics will be accumulated during these field tests; however, this is not a major objective of the program. Some of these tests will probably include organic particulate matter but will not include gaseous organics.

- "Emissions Characterization of Conventional Combustion Processes." Work in progress by TRW/GCA for the Chemical Processes Branch of IERL-RTP.

  This is a comprehensive program that will provide a definitive data base on VOC from combustion processes. Individual hydrocarbon species will be reported as well as total hydrocarbons. A draft report on residential oil-fired and coal-fired furnaces was submitted in October 1977, and is now undergoing revision prior to publication. A report on internal combustion oil and gas turbines and diesel engines is now being prepared. Reports on oil- and coal-fired industrial boilers and lignite-fired powerplants are scheduled for April 1978. Reports on coal-fired powerplants and commercial/institutional sources are anticipated for the future.

- "Control of Hydrocarbon Emissions From Stationary Sources in the South Coast Air Basin." Report prepared for the California Air Resources Board by KVB, Inc., which is to be issued in draft form in January 1978, and in final form later in the spring.

  This report includes field tests of two oil-fired steam plants, two oil-fired powerplant boilers, and one residential gas-fired heater. Detailed hydrocarbon species analyses were performed by GC-mass spec. techniques. Since the purpose of the study was to develop an emission inventory rather than to formulate emission factors, no detailed descriptions of the boilers are included.

- "Field Testing: Application of Combustion Modifications to Control Pollutant Emission From Industrial Boilers - Phase II," EPA-600/2-76-086a, April 1976. Cato, G.A. et al. Report prepared by KVB, Inc., for EPA under Contract No. 68-02-1074.

  Measurement of total hydrocarbons were made as an incidental part of this overall study. No species breakdown was attempted. Four coal-fired, four oil-fired, and five gas-fired boilers were tested. This work was completed after the most recent version of the corresponding AP-42 section was prepared.

- "Source Assessment: Industrial External Combustion Using Bituminous Coal in Dry Bottom Boilers, Furnaces, Etc." A multimedia report prepared by Monsanto Research Corporation that is scheduled for completion in January 1978.

  This report will include analytical data on hydrocarbon species, a summary of all published data, and will also be written in AP-42 format.

- "Source Assessment: Pulverized Bituminous Coal Firing Dry Bottom Utility Boilers." A multimedia report prepared by Monsanto Research Corporation that is scheduled for completion in January 1978.

  This report will include analytical data on hydrocarbon species, a summary of all published data, and will also be written in AP-42 format.

4.8 REFUELING MOTOR VEHICLES

The existing section in AP-42 was revised in April 1977, and as a result is relatively current. However, the motor vehicle refueling process is undergoing rapid changes as Stage II Vapor Recovery Regulations are implemented in California and other areas with severe air quality problems, and AP-42 will require frequent revisions to incorporate new data as they become available. The following documents include relevant information, but a thorough, definitive study of emissions has not yet been made because control systems are still under development.

- "Proposal of Stage II Vapor Recovery Regulations and Test Procedures," Federal Register, Vol. 41, No. 211, November 1976. U.S. Environmental Protection Agency.

- "Public Hearing on Vapor Recovery Regulations and Test Procedures, Phase II," held in San Francisco, California, April 1977. U.S. Environmental Protection Agency, Region IX.

  Most of the material presented at these hearings was not relevant to the development of emission factors, since it dealt with costs, testing procedures, and safety considerations. Reference was made to in-house tests conducted by Exxon, Texaco, Mobil, and the American Petroleum Institute, but no test results were presented.

- "Status Report on the California Program for Gasoline Vapor Recovery During Gasoline Marketing Operations." Staff report dated May 26, 1977. California Air Resources Board.

  This report contains good descriptions of vapor balance systems, and a status report on the California program for certification of devices with efficiency data for three of the 15 devices under consideration. A discussion is also given of problems associated with gasoline vapor recovery systems at service stations. Presumably at some future date a report of the completed California program will be issued, but such reports are not scheduled very far in advance.

- "Service Stations, State II." OAQPS Guideline Series scheduled for publication in December 1978.

  This report is expected to include a summary of all available data on performance of control systems but will not be a report of original field studies.

No discussion of total versus reactive organics has been presented, but factors can be estimated in a straightforward way from a knowledge of the gasoline composition.

4.9 PLASTICS FABRICATION AND FORMING

The factors listed in AP-42 are rated E since they are based on engineering analysis rather than field test data. This is a very diverse category that includes many kinds of plastics and

fabrication and forming operations, and as a result, would require a series of emission factors rather than a single factor. The following document provides a review of the industry.

- "Source Assessment: Plastics Processing - State of the Art." A report prepared by the Monsanto Research Corporation for EPA (IERL-Cincinnati) under contract. The draft version was issued in November 1977.

  In this assessment, no field tests were conducted. Emission factors were derived from information in the NEDS data base, and the numerical values are higher than those given in AP-42.

4.10 STATIONARY INTERNAL COMBUSTION ENGINES

This is a diverse category that includes diesel, gasoline, and gas-fired engines -- reciprocating and turbines -- in a wide range of sizes. Emission factors in AP-42 are rated A, B, or C depending on the type of engine, but VOC emissions are comparatively small and VOC emission factors are of secondary importance in determining the overall ratings. Reactive organics are estimated for gas-fired engines. A recent revision to Section 3.3.1 prepared by PES did not include any additions or changes in the hydrocarbon factors. As indicated herein, some work is in progress that will provide additional test data, but no comprehensive investigation of this varied source category is underway.

- "Emissions Characterization of Conventional Combustion Processes." Work in progress by TRW/GCA for the Chemical Processes Branch of IERL-RTP.

  As part of this comprehensive program, testing has been performed on internal combustion oil and gas turbines and diesel engines, and the report on these tests is now being prepared. Individual hydrocarbon species will be reported as well as total hydrocarbons.

- "Emissions From Ships, Ship Operations, and Transfer of Oil in the South Coast Air Basin." Work in progress by Scott Environmental Technology, Inc., for the California Air Resources Board. The report will probably be issued late in 1978.

In this report, the test program will include total hydrocarbon emissions from diesel-powered generators and a variety of engine types that are used for propulsion as well as pumping. At the present time there are no plans to analyze combustion exhausts for individual hydrocarbon species.

4.11 GRAPHIC ARTS

The prioritization scheme that was used in this report is based on a source classification system that categorizes graphic arts separately rather than including it as a subcategory under surface coating. There are many similarities between graphic arts and other types of surface coating processes, and the general remarks made in the Industrial Surface Coating Section of this report also apply to graphic arts. Estimation of emissions is a little more difficult since it requires knowledge of the composition of printing inks and similar coatings which are frequently considered proprietary. One report is being prepared in-house by EPA that may be useful.

- "Graphic Arts (Printing)." OAQPS Guideline Series scheduled for publication in June 1978.

  This report will emphasize control technology, but it will include a summary of some field test data that may be useful in developing emission factors.

In addition, two printing presses and one rotogravure press were tested in the KVB study on "Control of Hydrocarbon Emissions From Stationary Sources in the South Coast Basin."

4.12 GASOLINE SERVICE STATIONS

The current section in AP-42 was revised in April 1977, and includes an estimate of uncontrolled and controlled emissions. Stage I controls are relatively simple, and a substantial body of performance data has been accumulated in field situations, so this section should remain current for several years. Estimates of total versus nonmethane hydrocarbons can be made by the same techniques

that are used for other losses that result from volatilization of gasoline. The California Air Resources Board has conducted some testing of total hydrocarbon emissions from vents on underground storage tanks, but they are not engaged in a large, systematic evaluation. The control technology guideline document on Stage II controls has already been listed under Section 4.8 of this report.

4.13 BYPRODUCT COKE OVENS

The current section in AP-42 is based on reports published in 1967 and 1968, and the factors are rated C. Since that time, a limited number of studies have been carried out, but none for the purpose of developing emission factors. These are summarized herein. Laboratory and pilot plant studies are not included since, in the opinion of N. Plaks, they may not be representative of a full-scale coke oven operated under plant conditions.

- "Emission Testing of Ford-Koppers Coke Pushing System." Work recently completed by Ford Motor Company under contract with the Metallurgical Processes Branch of IERL. Testing was done by a subcontractor, Clayton Environmental Consultants. The report was published November 1977.

  This report deals primarily with the performance of a control system. A limited number of tests were done for low molecular weight organics, but no details of testing procedures are given.

- "Sampling and Analysis of Emissions From Coke Oven Doors." Study recently completed by Battelle Memorial Institute under contract to the Metallurgical Processes Branch of IERL. The report is now being prepared.

  The results of this report include species breakdown for condensable and noncondensable hydrocarbons. There is some question about the representativeness of the coke oven and the sampling technique. Battelle is continuing to work on coke oven door seals and may conduct full-scale tests on a demonstration system in late 1979.

- "Coke Quench Tower Emission Testing Programs." Work in progress by York Research under contract to the Metallurgical Processes Branch of IERL.

  Testing is underway and includes noncondensable and condensable hydrocarbons. The work is scheduled for completion early in 1978.

- Multi-Media Environmental Assessment of Ferrous Metallurgical Processes." Work in progress by Research Triangle Institute under contract to the Metallurgical Processes Branch of IERL (R. Hendriks).

  Sampling has been carried out on byproduct coke ovens for noncondensable and condensable hydrocarbons. The final report will presumably include a summary of test results from all sources including those done especially for this study. The contract continues until March 1980, with individual process reports issued from time to time.

4.14 SYNTHETIC RESIN MANUFACTURE

In the prioritization scheme used for this report, all synthetic resins were placed in a single category which received a final priority ranking of 14. If the various resin types had been prioritized individually, the following would have ranked highest:

Acrylic
Polyethylene
Polyvinyl chloride
Polystyrene

None of these, if listed separately, would have been included in the 20 highest priority sources. No work is in progress that treats the whole group of resins as a class, but some helpful reports have been published.

- "Special Project Report on Petrochemical Plant Sites." Report prepared by Monsanto Research Corporation for IERL-Cincinnati and issued on April 15, 1976.

  This report contains no text and is simply a computer-generated listing of (1) petrochemical plant sites, (2) material emitted and emission factors for each source type, and (3) an estimate of the data quality. Factors are given for each individual hydrocarbon species. This report includes the following synthetic resins:

  Acrylonitrile-butadiene-styrene resin

  Polycarbonate resins

  Polyethylene resin - low density

  Polyethylene resin - high density

  Polyvinyl alcohol resins

  In most instances, sufficient information is given to indicate whether any methane is produced or whether all organics are reactive. There are less than 20 plant sites for each of the resins previously listed, so an elaborate study to develop emission factors is not justified.

- "Source Assessment: Polyvinyl Chloride." Report prepared by Monsanto Research Corporation under contract to IERL-Cincinnati.

  The draft version of the report was issued in August 1977. Emission factors for vinyl chloride and polyvinyl chloride are given on an individual plant basis for 35 plants. Emission factors for 13 separate hydrocarbon species are given for a representative plant.

4.15 ETHYLENE DICHLORIDE MANUFACTURE, ETHYLENE OXIDE MANUFACTURE

These two industries are discussed together because they have identical priority rankings according to the system used. Both industries have a relatively small number of individual plant sites and might be ranked even lower because actual source test results could be used instead of emission factors for computing emissions. Ethylene dichloride manufacture is included

in the Monsanto report on Petrochemical Plant Sites previously discussed, and process study reports are scheduled to be issued under the Hydroscience contract during 1978.

4.16 DRYCLEANING

The current section in AP-42 was revised in April 1977, and is based on reports published in 1976 and 1977. Emission factors are rated B. No current studies have been identified, although two drycleaning plants were among the sources tested by KVB, Inc., in their emission inventory of the South Coast Air Basin for the California Air Resources Board.

4.17 NONPIPELINE TRANSFER OF PETROLEUM

The current section in AP-42 was revised in April 1977, and includes reports published late in 1976. Factors are given for loading of tank cars, trucks, tankers, and barges under a variety of conditions. In addition, factors are given for ballasting of tankers and for transit losses from tankers. No information is given on reactive versus nonreactive organics, but these estimations could be made by techniques applicable to any process involving evaporative losses of petroleum. Some work is in progress that could lead to improvement in some of these factors.

- "Emissions From Ships, Ship Operation, and Transfer of Oil in the South Coast Air Basin." Study in progress by Scott Environmental Technology, Inc., for the California Air Resources Board. The report will probably be issued late in 1978.

  In this report, the testing program is scheduled to include marine oil terminals, ship fuel docks, and marina fuel docks. The study will include a detailed survey of ship activities and movements with special emphasis on loading and unloading operations. Hydrocarbon species

will be measured, but the report will probably include only the three reactivity classes as defined by the California Air Resources Board. Probably the actual analytical results will be submitted also, so it should be possible to calculate the factors for reactive and non-reactive organics.

- "Hydrocarbon Emissions From Tanker Loading Operations." A study conducted by Chevron Research, Inc., for the Western Oil and Gas Association.

  This was a field study of eight tanker loading operations with total hydrocarbons measured in all tests and individual hydrocarbon species measured in selected tests. The final report is still undergoing final review prior to publication.

- "Background Information on National and Regional Hydrocarbon Emissions From Marine Terminal Transfer Operations," EPA-450/3-77-024, August 1977.

  This report is concerned primarily with movements of crude oil and gasoline on a national and regional scale. It may contain information that is useful to someone who is attempting to estimate emissions, but it does not deal directly with emissions factors.

- "Emissions From Ballasting." A study in progress by ESED and scheduled for completion in 1978.

  This study is monitored by the 831 committee and involves testing carried out by industry in response to 114 letters. It is not known whether a formal report will be issued, but test data on hydrocarbons can be obtained by contacting Dave Markwordt of ESED.

- "Ship and Barge Transport of Gasoline and Crude Oil." OAQPS Guideline Series scheduled for publication in December 1978.

  This is expected to be a summary of existing information and may include tests that are in various files at EPA but have not been formally published. The author of the report will be Dave Markwordt, but there is a possibility that plans may be changed and the report will not be published.

4.18 CHARCOAL MANUFACTURE

The current section in AP-42 was revised in April 1977, but it is based on data published in 1967. The factors are rated C. One relevant report has been issued since that time.

- "Source Assessment: Charcoal Manufacturing, State of the Art." This was prepared by Monsanto Research Corporation, under contract to IERL-Cincinnati.

  This report is said to contain no new test results, but it appears to include data that are not incorporated into AP-42. The report also implies that the organic emissions are 100-percent methane, but no description is given of any tests or methods.

4.19 VEGETABLE OIL MANUFACTURE

The current edition of AP-42 does not include a section on vegetable oil manufacturing, and no recent or current studies of the industry have been identified. The emission factor that was used to estimate emissions for prioritization purposes is based on a draft version of a 1971 document entitled "Background Information for Establishment of National Standards of Performance for New Sources, Vegetable Oil Industry." Apparently, a final version of the report was never published. A report on vegetable oil processing is scheduled for publication.

- "Vegetable Oil Processing." A control technology guideline document scheduled for publication by OAQPS in June 1978.

  This report is expected to emphasize control technology rather than emission factors.

5.0 NEEDS NOT CURRENTLY BEING ADDRESSED

In this section of the report the deficiencies and omissions discussed in Section 2.0 are compared with the accomplished and current research summarized in Section 4.0 to determine whether there are needs that are not currently being addressed. General needs are listed first and are followed by specific needs arranged by AP-42 section numbers.

- General Needs

  There appears to be no systematic effort to present hydrocarbon emission factors in a uniform format throughout the entire volume. Emission factors for methane, ethane, 1,1,1-trichloroethane, trichlorotrifluroethane, and possibly benzene should be given along with factors for total organics for each source type, and when such information is unavailable some statement to that effect should be made.

  Although AP-42 users did not seem particularly concerned, it was evident that the rating scheme for emission factors (A, B, C, D, or E) was frequently confusing. The rating seldom applies uniformly to factors for all pollutants, and it would be more meaningful if each factor were given a rating rather than applying a single rating to an entire table of factors. There seems to be no systematic effort underway to change this practice.

- Section 1 - External Combustion Sources

  None of the accomplished or current research will apparently provide emission factors for boilers that burn mixed fuel such as coal/refuse or oil/refuse. No studies are underway to provide factors for military fire-fighting schools, but there may not be enough need for these factors to justify a special study. It is uncertain whether residential heaters of modern design will be tested in any of the current research studies. There is certainly no large effort underway to compare older and modern heaters.

- Section 2 - Solid Waste Disposal

  No needs were identified by AP-42 users so no gaps exist. In the judgment of the authors of this report the practice of labeling hydrocarbon factors as (CH_4) and (C_6H_{14}) in some of the tables is not only unnecessary but also confusing and should be discontinued.

- Section 3 - Internal Combustion Engine Sources

  There may still be gaps left after the work in progress by TRW/GCA for CPB, IERL-RTP is completed. At the time of this writing, insufficient information was available to tell, but needs exist for more information on duty cycles as well as exhaust gas composition.

- Section 4 - Evaporation Loss Sources

  There appears to be no systematic research in progress to characterize the organic species emitted from afterburners or incinerators used to control solvent emissions. There may be sufficient data in widely scattered locations, but a substantial effort would be required to collect all of it, and no such effort is in progress. Apparently no changes in organization of this section of AP-42 are contemplated that would facilitate discussion of vapor balance systems as an integrated unit. Emissions from small storage tanks found at bulk plants may not be adequately addressed, but this cannot be determined until reports of ongoing studies are issued.

- Section 5 - Chemical Process Industry

  This area seems to be unique in that no needs were identified by AP-42 users, yet extensive studies are in progress to furnish improved data.

- Section 6 - Food and Agricultural Industry

  No work is underway to provide organic emission factors for various agricultural drying operations or to provide an AP-42 section on tobacco drying. No work was identified that would verify the existing factors for wine making.

- Section 7 - Metallurgical Industry

  No work is in progress to develop organic emission factors for secondary smelting operations, but these emissions are believed to be very small and not of major concern to AP-42 users.

- Section 8 - Mineral Products Industry

  There appears to be no effort underway to correct the apparent inconsistencies in the treatment of in-process fuel in the brick, cement, and lime manufacturing sections.

- Section 9 - Petroleum Industry

  The definitive field studies for this industry are still in progress, so it is impossible to determine whether gaps will still remain when these studies are completed. Because of the importance of this industry, these study results should be monitored carefully and incorporated into revised AP-42 sections as soon as possible.

- Section 10 - Wood Processing

  No needs were identified by AP-42 users, although it is apparent that one cannot readily derive an emission factor for total or reactive VOC from the factors as listed for RSH, RSR, and RSSR, and the note which states that these are usually expressed as sulfur.

- Section 11 - Miscellaneous Sources

  Since the needs with respect to natural and quasi-natural emissions have been evaluated elsewhere (Reference 6) they are not summarized here. No other needs were identified except possibly those related to military firefighting schools which have already been mentioned under Section 1 - External Combustion Sources.

The aforementioned listing is based on the assumption that those who are engaged in preparing inventories for modeling purposes do not wish to use AP-42 to obtain organic species breakdowns for each individual source type. It is anticipated that Vol. II, "Emission Inventory Input for Photochemical Modeling," which is being prepared by PES as a companion to Vol. I,

"Preparation of Emission Inventories for Volatile Organic Compounds," will contain instructions for the modeler to start with total organic emissions as calculated from AP-42 and accomplish the required species breakdown from data provided in Volume II.

6.0 PLAN FOR UPDATING AP-42

The survey of current and accomplished research (Section 4.0) indicated that several definitive field studies are underway and will be completed between the spring of 1978 and the fall of 1979. In addition, there are a number of AP-42 source categories that require improved organization rather than additional field test results to remedy their deficiencies. Finally, there are a number of AP-42 sections that are to be prepared by contractors as part of their reporting requirements. Even though some of these sources have low priority rankings, they should be added to AP-42 since minimal effort is required to do so. A plan is presented in this section for accomplishing these tasks in an orderly manner and is shown in tabular form in Table 6-1. Rough man-hour estimates are also given in Table 6-1. It is assumed that additional literature searches will be made as a part of each of the tasks listed herein.

6.1 TASKS FOR JANUARY THROUGH JUNE 1978

The following tasks are outlined for January through June 1978:

1. Start to prepare the following new sections of AP-42
   a. Industrial Surface Coating (major revision and expansion)
   b. Degreasing

Table 6-1. TIMETABLE AND MANPOWER ESTIMATES FOR AP-42 UPDATE

Source Categories	Major Reference	Time Schedule 1978	1979	1980	Action	Est. Man-hours[a]
External Combustion						
Industrial boilers	Monsanto SAD - Venesia				Review AP-42 write up, hold in file	20
Industrial boilers	TRW/GCA - Ponder				Update Monsanto write up	20
Coal-fired powerplants	TRW/GCA - Ponder				Revise existing section	80
Industrial boilers	EPA-600/2-76-086a				Review and hold in file	20
Residential	Monsanto SAD - Venesia				Review AP-42 write up, update if necessary	40
Residential	TRW/GCA - Ponder				Review and hold in file	20
Mixed fuel boilers	None identified				Review literature, initiate tests	[2,000]
General	All of the above				Update entire section 1. Reformat organic factors	200
Solid Waste Disposal						
Prescribed burning	EPA-600/2-76-032				Update, reformat Section 2.0	80
Coal refuse piles	Monsanto SAD - Harris, Hill				Review, add section if warranted	120
Resource recovery units	Future contract - CARB				Add section if warranted	120
Internal Combustion						
Oil and gas turbines	TRW/GCA - Ponder				Review and hold in file	20
Diesel engines	TRW/GCA - Ponder				Review and hold in file	20
Ship engines	Scott Env. Tech. - CARB				Review and update and reformat Section 3.3	200
Evaporation Loss						
Industrial surface coating	CTG, other reports				Major expansion of Section 4.2	(400)
Degreasing	CTG, other reports				Prepare new section	(140)
Textile finishing	Monsanto SAD - Samfield				Review AP-42 write up, add to AP-42	40
Solvent reclaiming	Monsanto SARD - Turner				Review, add section if warranted	80
Tank and drum cleaning	Monsanto SARD - Turner				Review, add section if warranted	80[c]
Graphic arts	CTG, other reports				Prepare new section	300
Storage of Petroleum						
Fixed roof tanks	Engr. Sci. for WOGA, also CTG				Review, update Section 4.3.2.2 if indicated	80
Floating roof tanks	CTG				Review, hold in file	20
Floating roof tanks	Engr. Sci. - (API)				Review, update Section 4.3.2.2 if indicated	120
General-types of VOC	General literature				Prepare special subsection (No. 5 under 6.1)	100
Trans., Mktg. of Petroleum						
Stage I	Possible future reports from CARB				Review, hold in file	20
Stage II	CTG				Review, hold in file	20
Ships, barges	Scott Env. Tech. - CARB				Review, hold in file	20
Ballasting	ESED - Markwordt				Review, hold in file	20
Ships, barges	CTG - Markwordt				Review, update and reformat Section 4.4	300
Chemical Process Industry						
Acrylonitrile mfg.	Monsanto SAD - Jefcoat				Review AP-42 write up, add section	20
Carbon black mfg.	Monsanto SAD - Jefcoat				Review AP-42 write up, add (or revise) section	20
Synthetic ammonia mfg.	Monsanto SAD - Venesia				Review AP-42 write up, add (or revise) section	20
Urea mfg.	Monsanto SAD - Venesia				Review AP-42 write up, add section	20
Chlorinated hydrocarbon mfg.	Monsanto SAD - Jefcoat				Review AP-42 write up, add section	20
Acetone and phenol mfg.	Monsanto SAD - Jefcoat				Review AP-42 write up, add section	20
Phthalic anhydride	EPA 600/2-76-032d				Review, update Section 5.12 if indicated	80[b]
Rubber processing	Monsanto reports - Turner				Review, prepare new sections as indicated	300
Plastics - polychloroprene	Monsanto SARD - Turner				Review, hold in file	20
Plastics - fabrication	Monsanto SARD - Turner				Review, revise Section 5.1, add Section ?	200
Plastics - polyvinyl chloride	Monsanto SAD - Turner				Review, hold in file	20

Table 6-1. TIMETABLE AND MANPOWER ESTIMATES FOR AP-42 UPDATE (CONCLUDED)

Source Categories	Major Reference	Time Schedule 1978	1979	1980	Action	Est. Man-hours[a]
Chemical Process Industry (continued)						
Plastics - general	Monsanto special report (see 4.14)	—			Review, hold in file	20
Ethylene dichloride mfg.	Hydroscience - Patrick		—		Review, add section if possible	100
Ethylene oxide mfg.	Hydroscience - Patrick		—		Review, add section if possible	100
Food and Agriculture						
Whiskey storage	ESED Report - Mascone	—			Review, update section 6.5 if indicated	80
Emissions from pesticide use	Eureka Labs - CARB	—			Review, add section if warranted	160
Alfalfa drying	None identified		—		Review literature, initiate tests	[2,000]
Grain drying	None identified		—		Review literature, initiate tests	[2,000]
Tobacco drying	None identified		—		Review literature, initiate tests	[2,000]
Wine making	No new work identified	—			Review literature, initiate tests	[2,000]
Metallurgical Industry						
Secondary smelting	None identified		—		Review literature, initiate tests	[10,000][c]
Coke mfg.	Battelle, York - Hendriks	—			Review, hold in file	20
Ferrous metallurgy	RTI - Hendriks	—	—	—	Review each report, update Section 7.0 as warranted	500
Mineral Reports Industry						
Brick, cement, lime mfg.	None identified	—			Correct inconsistent in-process fuel treatment	120
Cutback asphalt paving	AMTD - Lahre	—			Add section	20
Asphalt hot mix	Monsanto SAD - Turner	—			Add organic factors to recent revision	40
Flat glass mfg.	EPA 600/2-76-032b	—			Review, update Section 8.13 if warranted	80[c]
Petroleum Industry						
Refining	Radian contract - Masser	—			Check on AP-42 writeup, add revised section	40
Refining	Radian contract - Masser		—		Check on AP-42 writeup, add revised section	40
Oilfield production	Rockwell Int. - API		—		Review and prepare new AP-42 section	300
Oil and gas production	PES - Markwordt		—		Review and hold in file	20
Wood Processing						
General	None identified	—			Review literature, express organics as total VOC not as percent sulfur	40
Miscellaneous Sources						
Natural and quasi-natural	Midwest - Lahre		—	—	Add sections as data permits	Unknown
Natural gas leakage	RTI - Possiel		—		Add section, if possible	Unknown
Organization, Format						
Establish format for VOC factors		—			Prepare guide for AP-42 authors	40
Establish system for rating factors		—			Prepare guide for AP-42 authors	20

( ) Already in progress by PES
[ ] Presumably would be done by someone other than AMTB
[a] All estimates depend on the quality and applicability of the reference documents.
[b] A section on rubber tire manufacture is in progress by PES
[c] Low priority study.

2. Check on the following new sections that are to be written as part of contract reporting requirements:

   a. Petroleum Refining (prepared by Radian, now being printed)

   b. Acrylonitrile Manufacture (draft issued July 1977, Atley Jefcoat)

   c. Carbon Black Manufacture (draft issued August 1977, Atley Jefcoat)

   d. Synthetic Ammonia Manufacture (draft issued September 1977, Ron Venesia)

   e. Urea Manufacture (draft issued September 1977, Ron Venesia)

   f. Chlorinated Hydrocarbon Manufacture (draft due January 1978, Atley Jefcoat)

   g. Acetone and Phenol From Cumene (draft due January 1978, Atley Jefcoat)

   h. Residential External Combustion (draft due January 1978, Ron Venesia)

   i. Industrial External Combustion (draft due January 1978, Ron Venesia)

   j. Textile Finishing (draft due December 1977, Max Samfield)

   k. Cutback Asphalt Paving (draft due December 1977, Tom Lahre)

3. Examine the following reports and source assessment documents (final versions only) to see whether they contain material that should be incorporated into AP-42. Arrange for writeups when appropriate.

   a. Phthalic Anhydride (EPA 600/2-76-032d, December 1976)

   b. Rubber Processing (draft issued August 1977, Ron Turner)

   c. Asphalt Hot Mix (report being printed, Ron Turner). The recent AP-42 update did not incorporate factors for organics.

   d. Flat Glass Manufacturing (EPA 600/2-76-032b, March 1976)

e. Cost and Engineering Study - Control of VOC From Whiskey Warehousing (report available from David Mascone, ESED).

f. Any reports that have been issued on the TRW/GCA Combustion contract (W. Ponder).

4. Examine the following source assessment documents (final versions only) and decide whether the content warrants the addition of new sections to AP-42:

   a. Reclaiming of Waste Solvents (draft issued September 1977, Ron Turner)

   b. Rail Tank Car, Tank Trucks, and Drum Cleaning (draft issued January 1978, Ron Turner)

   c. Coal Refuse Piles (draft issued August 1977, Gene Harris and Ron Hill)

5. Prepare a subsection that lists the proportion of reactive and nonreactive organics for various kinds of petroleum fractions. Incorporate this into the AP-42 sections dealing with evaporative losses and fugitive emissions from petroleum.

6. Decide on a uniform system for listing hydrocarbon emission factors -- preferably omitting all references such as "as methane," "as hexane," "as C" which are unnecessary and confusing -- and adopt a uniform format for indicating the amounts of reactive and nonreactive organics.

6.2 TASKS FOR JULY THROUGH DECEMBER 1978

The following tasks are outlined for July through December 1978:

1. Obtain the following reports and augment and update the corresponding AP-42 sections:

   a. "Hydrocarbon Emissions From Fixed Roof Tanks," published by Western Oil and Gas Association and revisions, if any, to API Bulletin 2518 made as a result of this study.

b. "Emissions Assessment of Conventional Combustion Systems," as many interim reports as have been published by TRW/GCA. Check with Wade Ponder for progress.

c. "Sampling and Analysis of Emissions From Coke Oven Doors," by Battelle Memorial Institute and "Coke Quench Tower Emission Testing Program," by York Research. Obtain these reports from R. Hendriks and R. McCrillis.

2. Obtain the following report and backup data tape and use the data to specify the proportions of methane and nonmethane hydrocarbons for 24 source categories:

   1. "Control of Hydrocarbon Emissions From Stationary Sources in the South Coast Air Basin," prepared by KVB, Inc., for the California Air Resources Board. Contact Jack Paskind in the Research Division of the California Air Resources Board for the report.

3. Start to prepare the following new sections of AP-42:

   a. Plastics Fabrication and Forming (major revision and expansion) Refer to polyvinyl chloride source assessment document by Monsanto.

   b. Graphic Arts

   c. Synthetic Resin Manufacture

4. Establish a procedure with R. Hendriks for receiving process reports from the RTI Ferrous Metallurgy contract as they are issued.

6.3. TASKS FOR JANUARY THROUGH JUNE 1979

Perform the following tasks for the aforementioned period:

1. Obtain the following reports and augment and update the corresponding AP-42 sections:

   a. "Emissions From Ships, Ship Operations, and Transfer of Oil in the South Coast Air Basin," prepared by Scott Environmental Technology, Inc.,

for the California Air Resources Board. Contact Jack Paskind in the Research Division of the California Air Resources Board for the report.

b. "Fugitive Emissions From Oilfield Producing Operations," prepared by Rockwell International for the American Petroleum Institute. Contact API headquarters for the report.

c. "Evaluation of Emissions From Onshore Drilling Producing, and Storing of Oil and Gas," prepared by Pacific Environmental Services for EPA (David Markwordt).

d. "Emissions Assessment of Conventional Combustion Systems." Any additional interim reports (refer to Section 5.2)

2. Obtain the following reports and examine them to determine whether new sections of AP-42 are warranted:

   a. "Air Pollution Emissions Associated With Pesticide Applications in Fresno County," prepared by Eureka Laboratories for the California Air Resources Board. Contact the Research Division of the California Air Resources Board.

   b. "Evaluation of Emissions From Agricultural and Solid Waste Resource Recovery Units," proposed by the California Air Resources Board. Check with the Research Division of the California Air Resources Board for progress. This is scheduled for funding in 1978/79.

3. If appropriate, initiate literature and field studies that will provide VOC data for the following new sections of AP-42:

   a. Mixed fuel boilers

   b. Alfalfa drying

   c. Grain drying

   d. Tobacco drying

   e. Wine making

   f. Secondary smelting

4. Check with C.C. Masser about the progress of the Radian contract on emissions from oil refining. Make sure that the proposed writeup for AP-42 is in the most acceptable format.

6.4. TASKS FOR JULY THROUGH DECEMBER 1979

Perform the following tasks during the period July through December 1979:

1. Obtain a copy of the "Floating Roof Tank Emission Study" from the American Petroleum Institute and update AP-42 if necessary.
2. Continue to check with Wade Ponder for results from the TRW/GCA, "Emissions Assessment of Conventional Combustion Systems." Update AP-42 as required.

6.5. CONTINUING TASKS THROUGHOUT THE PERIOD

The following tasks should be continued throughout the period:

1. Monitor on-going research on natural and quasi-natural emissions -- especially softwood and hardwood forests, sewage treatment, commercial gas leakage, and sanitary landfills, and revise AP-42 as indicated.
2. Monitor Hydroscience contract (D. Patrick) and review reports as they are issued.
3. Monitor development of Stage II vapor recovery controls and revise Section 4.4 as required.
4. Check results of studies that develop detailed listings of hydrocarbon species measured in ambient air, especially the Tulsa study. Perform source reconciliation studies, if possible, to identify pollutants from area sources, such as leaking gas distribution systems, seepage from oil fields, and other natural sources. Try to develop emission factors for these natural and quasi-natural sources.
5. Maintain contact within EPA regions to learn of new needs for emission factors. It is anticipated that needs will arise in connection with new source review -- particularly where sources are subject to the emissions offset

policy. There have already been instances where a developer proposed to cut down a certain number of trees to offset hydrocarbon emissions from a new source. Proposals of this kind are expected to continue and may require better emission factors for trees and other natural sources.

APPENDIX A

The following PES personnel, who are all engaged in emission inventory projects, were interviewed to obtain their personal comments on AP-42. They, in turn, contacted individuals in the agencies with whom they are working to obtain additional comments in some instances.

Paradeep S. Bakshi (Petroleum storage and marketing)
Keith Duval (inventories for Washington, Oregon, Idaho)
Peter Kochis (inventory for Florida)
Robert Missen (inventories for Montana, Arizona, Hawaii)
Leslie Norton (petroleum production and refining)
Paul R. Peterson (petroleum storage)
Roy Sakaida (petroleum production, surface coating)
Joseph Trapasso (inventories for Kentucky, Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin)

Thr following agencies were contacted directly:

Maryland Bureau of Air Quality and Noise Control (E. Carter)
Illinois Environmental Protection Agency (Steve Tamplin)
Texas Air Control Board (Joe Pennington and staff)
California Air Resources Board (Frank Perry, Rich Bradley and staff)
South Coast Air Quality Management District (Wayne Zweicher)
Bay Area Air Pollution Control District (Dario Levaggi)
Monsanto Research Corporation (R.E. Opferkuch and staff)
EPA Region VI (O. Cabra)
Denver PACD (Thomas Peabody)
Dayton Regional Air Pollution Control Agency (G.C. Selnick)

APPENDIX B

This appendix lists current and recently completed work that was investigated during the course of this study and was not discussed in Sections 4.0 or 6.0. This listing includes all work (except individual source tests) regardless of its applicability to emission factors or the priority rating of the source category. For convenience, these studies are grouped according to the organization of AP-42.

1. External Combustion Sources

"Emissions From Residential and Small Commercial Stoker-Coal-Fired Boilers Under Smokeless Operation," EPA-600/7-76-029, October 1976. Contains measurements of polycyclic organic matter but does not include gaseous hydrocarbons.

"Field Testing: Trace Element and Organic Emissions From Industrial Boilers," EPA-600/2-76-086b, October 1976. Contains measurements of three polycyclic organic compounds but does not include gaseous hydrocarbons.

"Preliminary Emissions Assessment of Conventional Stationary Combustion Systems, Volume II - Final Report," EPA-600/2-76-0466, March 1976. Paper study that summarizes existing data.

"Coal-Fired Stoker Industrial Boilers," in progress by American Boiler Manufacturing Association under contract to IERL-RTP (joint with ERDA). Expected to include polynuclear organic matter but not gaseous hydrocarbons. Report due in the fall of 1978.

"Survey of Environmental Assessment of Conventional Combustion Processes," in progress by Research Triangle Institute under contract to IERL-RTP. Paper study to summarize current activities and plan additional efforts. Report due March 1978.

"Emission Estimates of NO_2 and Organic Compounds From Coal-Fired Fluidized-Bed Combustion," pp. 1015-1023 in EPA-600/3-77-001b, January 1977. Contains data on concentrations of several hydrocarbon species including methane.

"Characterization of Discharges From Coal-Fired Utility Boilers," in progress by TVA under an interagency agreement with IERL-RTP. A multimedia study that is expected to include some measurements of gaseous emissions.

"Evaluation of Wood-Fired Boilers in the State of Vermont," in progress by GCA under contract to IERL-RTP. Major emphasis is on particulates rather than hydrocarbons.

"Hydrocarbon Characterization of Agricultural Waste Burning," in progress by the University of California, Riverside, for the California Air Resources Board. This is a test program, but burning will be done in a test facility -- not in the field.

2. Solid Waste Disposal

"Source Assessment: Agricultural Open Burning, State of the Art," EPA-600/2-77-107a, July 1977. Paper study that relies heavily on AP-42.

"Source Assessment: Prescribed Burning, State of the Art," EPA-600/2-76-032, May 1977. Paper study that includes several recent references that are not listed in AP-42, and also includes data on hydrocarbon species.

3. Internal Combustion Sources

All work was discussed in Paragraph 4.10.

4. Evaporation Loss Sources

"Source Assessment: Rail Tank Car, Tank Truck, and Drum Cleaning, State of the Art," draft report prepared by Monsanto Research Corporation for IERL-Cincinnati, September 1977. Includes a few exploratory field tests.

"Source Assessment: Reclaiming of Waste Solvents, State of the Art," draft report prepared by Monsanto Research Corporation for IERL-Cincinnati, January 1978. Includes some exploratory field tests.

"Fugitive Emissions From Stock Tanks," in-house study in progress by the Texas Air Control Board. Does not include field testing but is merely a tank inventory.

"Evaluation of Methods for Controlling and Measuring Emissions From Petroleum Storage Tanks," EPA-450/3-76-036, July 1977. Does not include any test data.

"Evaluation of Hydrocarbon Emission Control Strategies for Gasoline Marketing Operations," draft report prepared by Pacific Environmental Services under contract to EPA, OTLUP, December 1977. Paper study that does not include emissions testing.

"Development of Control Techniques Document for Factory Surface Coating of Flat Wood Products," in progress by Pacific Environmental Services for ESED. Paper study that does not include emissions testing.

5. Chemical Process Industry

"Industrial Process Profiles for Environmental Use: Chapter 5 Basic Petrochemicals Industry," EPA-600/2-77-023e, January 1977. Paper study that emphasizes process descriptions rather than emissions.

"Source Assessment: Polychloroprene, State of the Art," draft report prepared by Monsanto Research Corporation for IERL-Cincinnati, July 1977. Includes emission factors for individual hydrocarbon species obtained from personal communications with several industry representatives.

"Source Assessment: Maleic Anhydride, State of the Art," in preparation by Monsanto Research Corporation for IERL-Cincinnati, due December 1977. Will include few, if any, field tests.

"Source Assessment: Acrylic Acid Manufacture, State of the Art," in preparation by Monsanto Research Corporation for IERL-Cincinnati. Due January 1978. Will include few, if any, field tests.

"Overview of Textile Manufacture," special report prepared by Monsanto Research Corporation for IERL-RTP, August 1977. Multimedia report with very little field testing.

"Pollutants From Synthetic Fuels Production," work in progress by Research Triangle Institute for IERL-RTP. Paper study with no field tests.

"Rubber Products Manufacture," control technology guidance document scheduled for publication by OAQPS in June 1978. Paper study with emphasis on control technology.

"Paint Manufacture," control technology guidance document scheduled for publication by OAQPS in June 1978. Paper study with emphasis on control technology.

"Synthetic Organic Chemical Manufacturing Industry Study," in progress by Hydroscience, Inc., for ESED (Dave Patrick). Multimillion dollar, multimedia study to be conducted between March 1977 and March 1980, to gather data necessary to develop NSPS and CTG's for VOC emissions from organic chemical manufacturing. The data would also support development of NESHAPS for benzene and other organic hazardous pollutants. Reports on 73 processes are scheduled during 1978 with 200 - 300 processes scheduled for the two following years. A year-end report on the study was prepared by Dave Patrick in December 1977.

6. Food and Agricultural Industry

"Source Assessment: Beef Cattle Feedlots," report prepared by Monsanto Research Corporation for IERL-RTP, July 1977. Contains no information on hydrocarbons.

"Source Assessment: Defoliation of Cotton," report prepared by Monsanto Research Corporation for IERL-RTP, July 1977. Contains no information on hydrocarbons.

"Source Assessment: Pollution Potential for Chemical and Fertilizer Industry," report prepared by Monsanto Research Corporation for IERL-Cincinnati, January 1978. Contains no information on hydrocarbons.

"A Study to Determine Air Pollution Emissions Associated With Pesticide Applications in Fresno County," in progress by Eureka Laboratories for the California Air Resources Board. Report expected in summer 1978. Will include as much field testing as is necessary to compile an emission inventory.

"Cost and Engineering Study - Control of VOC Emissions From Whiskey Warehousing," a report prepared by ESED (David Mascone) in 1978. Essentially a material balance study using data from whiskey tax records.

7. Metallurgical Industry

"Enclosed Coke Pushing and Quenching System Demonstration," now being completed by National Steel Corporation under contract to IERL-RTP. Attempts were made to measure some hydrocarbon emissions, but little useful data were produced.

"Development of Technology for Controlling BOP Charging Emissions," now being completed by National Steel Corporation under contract to IERL-RTP. Some attempts were made to quantify gaseous hydrocarbons, but little useful data were produced.

"Treatment of Gaseous Emissions From Steel Plants Containing Small Concentrations of Hydrocarbon Vapors," grant to Massachusetts Institute of Technology from IERL-RTP with matching funds from AISI. This is expected to be basic science done on a laboratory scale that will not lead directly to emission factor development.

"Organic Emissions From Sinter Plants - Determination of Causes and Methods of Abatement," grant to the University of Pittsburgh from IERL-RTP with matching funds from AISI. This will be bench scale work with detailed analysis of hydrocarbon species.

"Standards Support and Environmental Impact Statement - An Investigation of the Best Systems of Emission Reduction for Sinter Plants in the Iron and Steel Industry," in-house draft document prepared by ESED, May 1977. Includes a few tests of gaseous hydrocarbons and some information on hydrocarbon species.

"Uses and Fate of Lubricants, Oils, Greases, and Hydraulic Fluids in the Iron and Steel Industry," now being completed by Pacific Environmental Services under contract to IERL-RTP. Does not include any estimates of air emissions.

"Emissions From Iron Ore Mining, Beneficiation, and Pelletizing," now being completed by Midwest Research Institute for IERL-RTP. Test data are too limited to lead to emission factor development.

"Emissions From Copper Smelting," study performed by Bor Copper Institute for IERL-RTP. Report was received in 1975 but has not been published. Does not contain data on hydrocarbons.

"Emissions From Lead and Zinc Smelting," study performed by Trepca Lead and Zinc Institute for IERL-RTP. Report was received in 1975 but has not been published. Does not contain data on hydrocarbons.

8. Mineral Products Industry

"Source Assessment: Asphalt Hot Mix," prepared by Monsanto Research Corporation for IERL-Cincinnati, July 1977. Includes limited test data on total gaseous hydrocarbons and aldehydes, and more test data on polycyclic organic matter.

"Source Assessment: Flat Glass Manufacturing Plants," EPA-600/2-76-032b, March 1976. Includes no original test data, but lists emission factors derived from existing data.

"Source Assessment: Coal Refuse Piles, Abandoned Mines and Outcrops, State of the Art," prepared by Monsanto Research Corporation for IERL-Cincinnati, August 1977. Includes exploratory tests for total hydrocarbons and polycyclic organic materials.

"Source Assessment: Brick Kilns," prepared by Monsanto Research Corporation for IERL-Cincinnati, October 1977. Does not include any original test data for hydrocarbons.

9. Petroleum Industry

"Survey of Compliance Status and Study of Air Pollution Problems and Controls at Petroleum Refineries," prepared by Pacific Environmental Services for EPA, DSSE, April 1977. Does not include any field testing.

"Offshore Oil and Gas Development: Southern California," prepared by Environmental Research and Technology, Inc., for the State of California Office of Planning and Research and the Santa Barbara County Department of Environmental Quality, March 1977. Does not include any field testing.

"Multimedia Assessment of Environmental Effect of Natural Gas Processing Plants," in progress by TRC under contract to IERL-RTP. Report due March 1978. A paper study that emphasizes control of nonmethane hydrocarbon emissions.

10. Wood Processing

"Measurement of Volatile Emissions From Wastewater Basins," grant from IERL-Cincinnati to the University of Arkansas. Expected completion September 1979. This study emphasizes odors and does not deal with total hydrocarbons.

11. Miscellaneous

"Vegetation Hydrocarbon Emission Inventory for Tampa Bay," performed by Washington State University under contract to EPA Region IV. Report is now being prepared.

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